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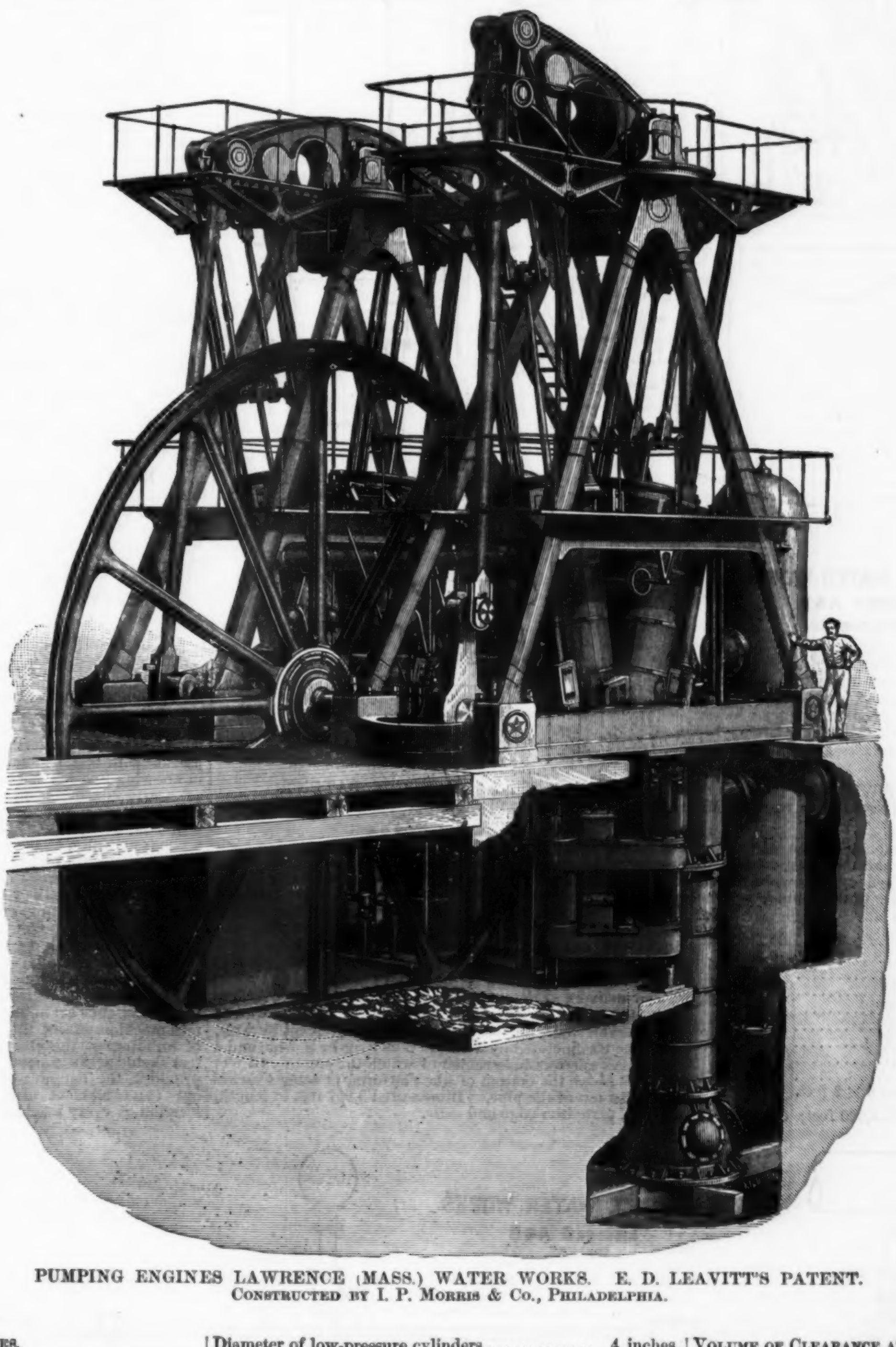
PUMPING ENGINES OF THE LAWRENCE (MASS.) WATER WORKS.

We have before us the report of Messrs. W. E. Worthen, J. C. Hoadley, and Jos. P. Davis, the Board of Experts charged with making test trials of the compound pumping engine built under E. D. Leavitt, Jr.'s, patent, by I. P. Morris & Co., of Port Richmond Iron Works, Philadelphia, for the water works of Lawrence, Mass. A perspective view of the engines is given in Fig. 1. Fig. 2 is a section of one engine, and Fig. 3 exhibits sections of the boilers.



PUMPING ENGINES LAWRENCE (MASS.) WATER WORKS. E. D. LEAVITT'S PATENT.
CONSTRUCTED BY I. P. MORRIS & CO., PHILADELPHIA.

THE ENGINES.

There are two engines having a single fly-wheel between them. The two steam cylinders, both steam jacketed, are placed beneath the main centre of a working beam, and are inclined outwardly at the top to connect with opposite ends of the beam. In this way the length of steam passage between the cylinders is reduced, the stroke equalized, and space economized. The cylinder valves are all gridiron valves, with large area of opening and small movement. The steam valves to the high-pressure cylinders are operated by cams controlled by governors, one to each engine. When running coupled, the cam of one engine is set and the other is controlled by its governor. The air-pump is double-acting, and to its rod the feed pump is connected. The pumps are of the Thames Ditton variety, bucket and plunger, but with supplementary delivery pipe. There are seven double-beat valves for suction, and four in the supplementary pipe. Attached to the lower valve chamber there is a small spherical chamber, with an air-cock at the top, by which air may be introduced into the pump. In certain stages of water in the well the pump is thus caused to work more easily. The

DIMENSIONS

of the engines are shown in the following:

Diameter of high-pressure cylinders	18	inches.
" low " "	38	"
" high " " rods	3¼	"
Diameter of low-pressure cylinders	4	inches.
" air-pumps	15	"
" pump-barrel	26½	"
" " plunger	18½	"
" " " rod	4½	"
" bottom and supplementary valves outside lower seat	15½	"
" bottom and supplementary valves inside upper seat	12½	"
" bucket-valves outside lower seat	22	"
" " inside " "	15	"
" air-chamber	54	"
" fly-wheel	30	feet.
Length of stroke of steam and water pistons	8	"
" " air-pump	28	inches.
Distances between End Centers of Beam	16¼	feet.
Lead on steam-valves	0	
" high-pressure exhaust valves	1/16	inch.
" low " inlet	1/16	"
" " " exhaust bottom	3 5/16	"
" " " " top	4 9/16	"

All measured on stroke of pistons.

Cushion on high-pressure top exhaust	14½	"
" " bottom "	14½	"
" low-pressure top "	4½	"
" " bottom "	8¼	"

VOLUME OF CLEARANCE AND PORT SPACE:

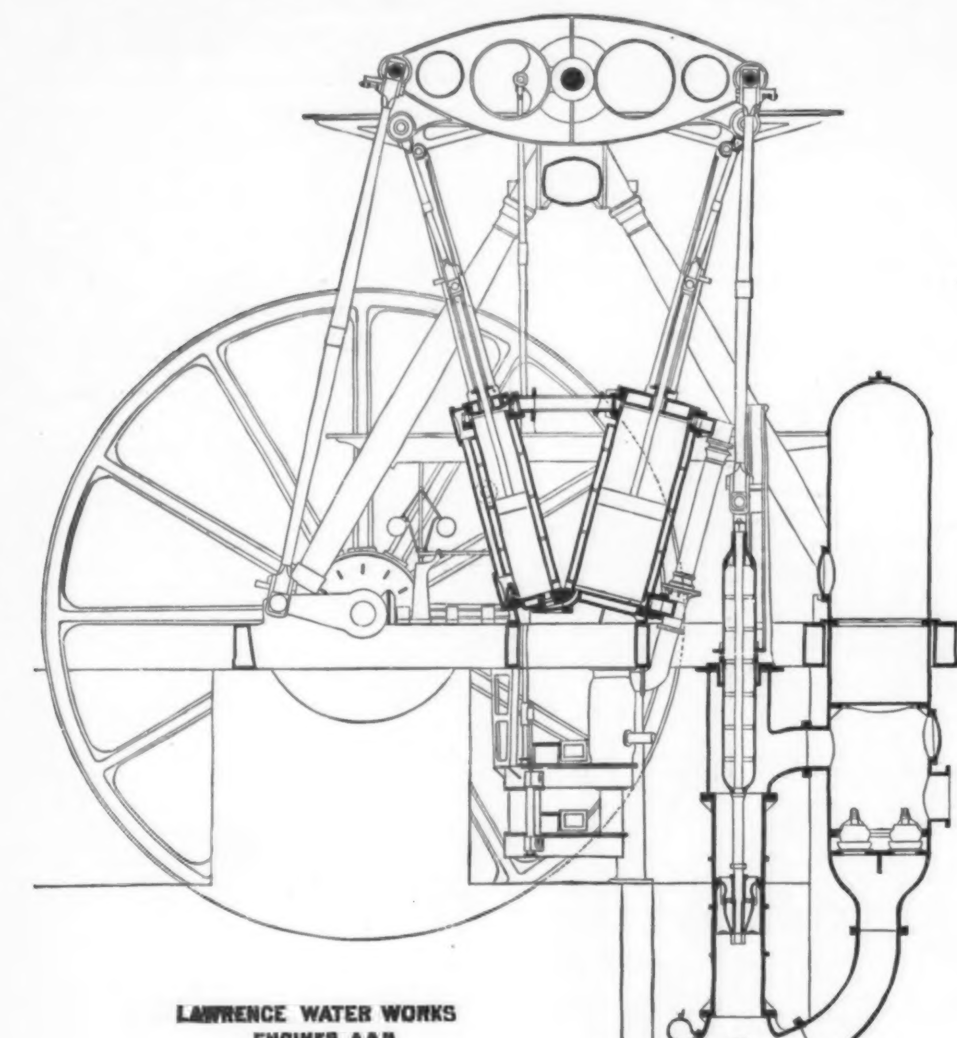
High-pressure top	·0256	of cylinder capacity.
" " bottom	·0231	" "
Low " top	·0154	" "
" " bottom	·0182	" "
Connecting pipe between cylinder	·0992	H. P. " "

Weight of fly-wheel	35,900	lbs.
" walking-beam, including pins and counter-balance	25,700	"
" high-pressure piston and connections	2,575	"
" low-pressure piston and connections	4,175	"
" air-pump piston and connections.	1,800	"

Weight of pump, plunger bucket	7,200 lbs.
" main connections, beam to crank	3,800 "

THE BOILERS,

Fig. 3, are two in number, tubular, with interior fire-boxes. A water mid-feather divides each boiler into two furnaces, and extends from the front nearly to the center of boiler, where both fire-boxes unite in one combustion chamber.



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From this chamber the boiler is tubular to the end. The products of combustion pass through the tubes, return beneath nearly to the ash-pit, and thence go downward and laterally into a depressed flue leading to the chimney. The dimensions of the boilers are:

Length of shell	25 ft. 5¼ in.
" water mid-feather..................	12 feet.
" combustion chamber	3 "
" tubes..................................	10 "
Diameter of tubes..............................	3 inches.
Number "	80.
Diameter of circular shell....................	5 ft. 3 in.
Length of each grate	5 feet.
Width " "	2 ft. 10 in.

Steam drum for both boilers, 12 feet 6 × 2 feet.

The length of the force main is 4,900 feet; diameter, 30 inches; branches from engines to main, 75 feet long by 42 inches diameter; and static lift from 165 to 174 feet. The

CONDITIONS OF TEST

called for in the contract may be summarized as follows: The engines were to run 48 hours consecutively, during which time the water was to be measured over a weir at the reservoir. The delivery of the pumps was required to be at the rate of at least 2,000,000 gallons in ten hours for each engine, with a speed of sixteen revolutions per minute, and a steam pressure in the boiler of ninety pounds per square inch. The duty obtained was required to equal 95,000,000 pounds lifted one foot high for every hundred pounds of coal consumed in the boiler furnaces during the trial, said duty to be reckoned upon the amount of water delivered over the weir at the reservoir, with 5 per cent. added thereto to allow for loss of action at the pump.

The delivery at the water works is usually by an overflow from the upright pipe on the center of the division wall of the reservoir; but, for the purpose of measurement by weir, this pipe was inclosed by a box 10 feet long by 8 wide and 4 deep. A weir was constructed of which the crest was 2 feet 4 inches above the bottom of the platform, or some 4 inches above the top of the pipe. It measured 3,997 feet in length, and had plate iron edge and sides.

THE TRIAL

began at 4.16 P.M. on May 1, 1876, and the tests continued upon the engines, singly and coupled, until 6 P.M. May 6. The results, in conformity to the requirements of the contract, are as follows:

Capacity.—For a period of 22 hours, on May 2, there was delivered into the reservoir, as measured by the weir observations, taken at intervals of not more than five minutes, 4,527,340 gallons, or 2,057,881 gallons per 10 hours; revolutions, 16·25 per minute; boiler pressure, 90 pounds. During 35 hours, on May 3 and 4, the delivery was 7,261,209 gallons, or 2,074,681 gallons per 10 hours; revolutions, 16·29; boiler pressure, 89 pounds. In both cases a large excess over the delivery called for by the contract is shown.

Duty.—During the first period above mentioned, the left was 75·96 pounds, or 75·96×2·31=175·47 feet. Delivery of water, as above stated, was 4,527,340 gallons. Adding 5 per cent. to this, and multiplying by 8·38, weight of 1 gallon in pounds, we have 39,836,064 pounds, which multiplied by 175·47, and divided by the coal consumed, 7,266 pounds, gives as the duty of 1 pound of coal 962,019 foot pounds.

In the 35 hours test the left was 175·07 feet, and by a similar calculation a duty of 961,776 foot pounds per pound of coal is determined. The average of the two tests for the 57 hours gives 96,186,979 pounds lifted one foot high by 100 pounds of coal.

This remarkable result is substantiated and more clearly exhibited by the calculations which the engineers append, based on the data obtained per indicator card. The following are the details:

Diameter of high-pressure cylinders 18" area	254·47 sq. in.
This will be effective area of bottom of piston ; of the top it will be less the area of piston rod, or 254·47 — 9·62	244·85 "
Diameter of low-pressure cylinder 38" area	1134·11 "
Top area of piston 1134·11—12·57 ...	1121·54 "

During the 22 hours' test the average pressure by planometer were—

Top high pressure,	51·65× 244·85=	12646·5	
Bottom " "	55·01× 254·47=		13998·4
Top low "	19·82×1121·54=	12135·1	
Bottom " "	9·59×1134·11=		10876·1
		24781·6	24874·5

or total, 49656·1. The length of stroke was 8 feet, number of revolutions 21,444, and coal consumed 7,266 lbs. Hence,
$\frac{49656 \cdot 1 \times 21{,}444 \times 8}{7266} = 1{,}172{,}365$ pounds feet per pound of coal. Since 1 HP=1,980,000 pounds feet per hour $\frac{1{,}980{,}000}{1{,}172{,}365} = 1 \cdot 69$. Or, we have the result of *one indicated horse power for every* 1·69 *pounds of coal fed upon the grates.*

The 35 hour test gives 1,175,508 pounds feet per pound of coal, or 1 indicated horse power per 1,684 pounds of coal per hour.

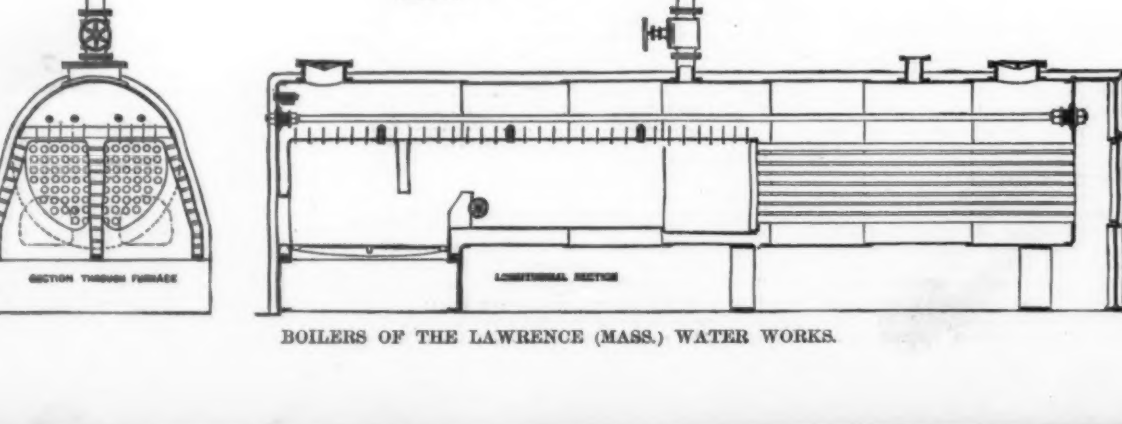
The Board of Experts adds, by way of conclusion: "With regard to material and workmanship, the engines are strong, compact, well made, and, in disposition of material, good examples of mechanical engineering. In their future working we feel sure that they will be serviceable and economical, and that the duty now arrived at could be readily surpassed after longer working and acquaintance with the machines and their appliances."

HANGING AND CARE OF SHAFTING

By Jesse Lord.

No proprietor of a manufacturing establishment where power is used—steam or water power—but should see that he gets a *quid pro quo* from the power furnished; that is, that he gets a proper proportion of the power developed in comparison with that generated. This is important, not alone in knowing that his machines, driven by power, are running as nearly constantly as possible, but that there be as little waste of power between the prime mover and the ultimate result as possible. One item of preventing waste is attention to the proper hanging of shafting, and its after care. A line of shafting running true, smoothly, almost noiselessly, is a delight to the mechanical eye. The first look of a practical visiting mechanic, as he enters a manufactory, is an upward look—to the shafting. If the line runs true, and the pulleys do not "wabble," and there is no grinding nor squeaking, nor exudation of oil at the ends of the boxes, he mentally, if not vocally, declares that the mechanic who hung that shafting knew his business.

The hanging of shafting is as important a department of the millwright's art as the construction of the building to contain machinery is of the architect's; in fact, in the erection of buildings of this character, the millwright and the architect should act in concert. But when a proper building is provided, the hanging of the shafting should be intrusted only to a competent man, one who can previously plan the location of every machine on the floor, and the position of



BOILERS OF THE LAWRENCE (MASS.) WATER WORKS.

every pulley on the main line, if not on the counters. Then he can know just where his hangers or brackets should be to best sustain the weight of the heavy pulleys, and the proper intervals between them, to prevent sagging of the shaft when at rest, and its springing when in motion. If the shaft is supported by brackets on posts, an approximation to a level may be made by stretching a chalk line along the posts and designating the top or bottom of the brackets, or the center line of the shaft on the posts. Although the line, if stretched a considerable distance, will sag some, it will be a sufficient guide for the boring of the bolt-holes. The rectification of this line can be effected, after the boxes are placed by means of a water level—a sighting level, or some similar device—the eye being entirely reliable in testing a right line, although not trustworthy as to level. To ascertain the level, a straight edge, of good seasoned pine, planed accurately on both edges, strictly parallel, and wide enough to prevent sagging, and long enough to reach from one box to the next, should be provided. In use, one edge should be rested in the boxes, and on the other should be placed a spirit level. This is a simple but effective device. Of course it is equally applicable to hangers and brackets.

Shims for leveling down hangers should be of wood, not leather; a yielding material, not iron wedges, generally made too narrow to give a good bearing. Probably nothing is better than seasoned, rived, cedar shingles, which are almost as hard as horn. Bolts to hangers are perhaps necessary for very heavy shafting, but they have been largely superseded by lag screws, or, as some call them, coach screws. If bolts are used the heads should be slightly convex, strengthened by washers under the head, and both washer and head partially sunk into the floor. When lag screws are used, the holes for their reception should be bored only as large as the core of the screw, leaving the thread to make its own way through the wood.

Shafting is continually getting out of line or of level, from one cause or another; the walls of the building may settle, or the floor may be depressed in one spot by an unusual weight; a heavy strain by a belt may cause a cutting of a box and consequent derangement of the line. Frequent, periodical inspections should be made to readjust hangers and brackets, if necessary, and to ascertain if there is undue strain on any particular portion. Neglect of these duties will surely cause waste and expense.

THE DETROIT TUNNEL.

THE projected methods for tunneling the Detroit river increases wonderfully in number under the stimulus of an invitation from the committee to submit plans. Gen. Smith's plan has been examined by the committee appointed by the Mayor of Detroit, and has been pronounced feasible. Mr. D. Farrand Henry presented plans made in 1874, when this subject was before discussed. Mr. William Scott and Mr. Henry Collins both propose tunnels in different locations, the former putting the cost at $2,500,000, and the time two years, and the latter making his figures $2,268,000, at which sum he offers to contract to excavate it. Mr. Hall, of Mt. Clemens, proposes to sink a boiler plate tube coated with tar and gravel, to make it impervious to water. Mr. H. M. Cargill, of Grand Rapids, proposes to bore a tunnel with an earth auger, with appliances for removing boulders and other obstructions, working his machinery by compressed air. He estimates the cost at $2,500,000. Mr. McWilliams, whose scheme we alluded to on February 10, reckons the expense at $150 per lineal foot, the tunnel to be 22 feet in diameter. Oliver Drouillard desires to sink iron tubes, weighted with masonry on either side, at an estimated cost of about $200,000. Another ingenious inventor proposes to solve the difficulty by quite another method, that is to bridge to and from Belle Isle, and to build a canal through the island for the benefit of vessels. Mr. Luther Beecher thinks that he can tunnel underground for $100 per foot.

Mr. John Burt, the chairman of the committee, proposes to start directly from the Michigan Central Railroad depot, thence to curve to the foot of Woodward avenue, and thence to cross the river directly, making a length of 5,280 feet. This plan contemplates the construction of a double-track tunnel, in caissons from 100 to 200 feet in length, across the entire bed of the river, the tunnel to be made of brick, in a timber caisson, with temporary bulkheads, floated out, manœuvred by tugs and sunk in line by means of guide timbers attached to the caissons already down. When bottom is reached, access is to be had to the caisson by iron shafts, the water is to be forced out by compressed air, or to be pumped out in case the caisson has taken the bottom sufficiently to exclude the water, and then excavation is to be carried on beneath until the caisson with its included tunnel is lowered to the required depth in the trench. He proposes to run hydraulic cement into a cavity left in the brickwork at the joint in order to make this portion tight.

But enough of these projects, some of which are more curious than practicable; we will only say that Mr. Chesbrough has again given his opinion to the committee that a tunnel can be constructed for $3,000,000, leaving out of consideration the value of real estate which might be taken for approaches. As to the pecuniary prospects, they are favorable to the venture. New York capitalists have signified that at least $2,000,000 can be obtained on tunnel bonds at 6 per cent. interest, if guaranteed by the city of Detroit. It seems to be the general opinion that Detroit can well afford to devote $500,000 to the project. Mr. Joy stated that he would be willing to promise that the railroad companies would agree to use a tunnel, provided one was constructed, and to pay annually $200,000 in tolls. Steps for organization of a company have already been taken, and we hope that, upon the definite report of the committee, the matter will be vigorously entered upon.—*Engineering News.*

THE KIND-CHAUDRON SYSTEM OF SINKING MINING SHAFTS.

The following is a description of this method, as now operated at the Cannock and Huntington collieries, near Huntington, Yorkshire, England:

"On approaching the colliery, the first thing that will strike the visitor is the very high and novel-shaped wooden shed which stands over pit No. 1 (the other, No. 2, is being erected). A large foundry shed and a very fine chimney shaft will also attract attention. The chief interest at present, however, centres in the operations in the pit-shed. To enter this, the visitor will have to mount up steps a height of some 15 or 20 ft. above the surface of the ground. Passing through the door at the top, he will find himself in what, for want of a better subject for comparison, we may describe as a very lofty barn with a boarded floor. Having arrived here, he will perhaps ask where the shaft is that is being sunk, for nothing is to be seen of it. In the middle of the floor, however, there is a circular hole of about 1 ft. in diameter, and, if the boring is going on, through this will pass an iron rod, which is suspended by a gigantic screw and chain to the end of an oak beam some 10 ft. above the floor. A capstan bar through the rod, manned by four laborers, completes all the boring apparatus that is at first sight visible. The end of the beam from time to time slowly rises for about 2 ft. and suddenly drops again, letting the rod and all that is suspended to it underneath the floor fall with it, the men at the capstan bar walking slowly round as the boring rod rises and falls.

"While this monotonous process is going on, the machinery which works the beam and that which rises the tools can be examined. The beam, which projects into the shed from a building joining on to it and which we may call an *annexe*, is of oak and is about 25 ft. long; its further end is attached to and is drawn down by a piston working in a large cylinder fixed below the beam, and to this steam is admitted at intervals. The beam, therefore, pulled down by the piston at one end and by the weight of the boring apparatus at the other, oscillates under the control of the engineer.

"Having examined the beam, we may pass further on into the *annexe*, and inspect the steam engine which supplies the power necessary to raise and lower the boring apparatus. This engine is a powerful one, working a train of cog wheels, the last carrying a drum, round which an enormous rope is wound. This rope, it will be seen, passes up a covered way to the pulley at the top of the pit-shed, where it hangs, high up overhead, ready for use. The time at length arrives for lowering the dredge, or basket, and if the visitor will return to the shed he will see this operation. At a signal from the chief borer, the motion of the beam is stopped, two baulks of timber are slid up on each side of the boring rod, and an iron fork, or key, is laid on them, which just admits through it the passage of the smaller part of the rod, but not of the shoulder of and screw-joint in it; the beam is slightly lowered, and the whole weight of the underground apparatus is borne by the timber we have just spoken of. The chain and screw, with the heavy iron swivel at the end of them, are detached from the rod of the boring apparatus, and the connection between them and the oscillating beam is severed. The rope now descends from the top of the pit-shed, and being hooked on to the end of the beam, lifts it gently up; the men are ready at their posts, and a roller having been slipped under the other end, the whole mass of oak to its iron attachments, weighing some five or six tons, is quietly slid back, and laid to rest out of the way for a time, as gently as if it were a baby being turned over in its cradle. The rope now descends again, is attached to the boring rods, and, in a few seconds, the first length is raised above the ground, through the hole in the floor we first mentioned; the iron key is again brought into use, while the upper rod is detached and put on one side; the rod in the drill is at length reached, and when this is made fast to the rope, the men rapidly remove the floor boards in the middle of the shed, and the observer finds himself standing at the edge of the pit-mouth. On looking down it will be seen that underneath is a circular shaft, of some 20 ft. diameter, full of water. The surface of the water is now, perhaps, not more than 15 ft. below the floor of the shed; but when the lower water-bearing strata are reached will probably rise some feet higher. The engine now moves again, and the drill is brought into daylight. As soon as it appears the floor boards are replaced, and this part of the apparatus can be approached and examined. When we call the boring tool a drill, we do so for want of a better expression, and not that the word properly describes the implement in question. The one now being used at Huntington, which excavates a shaft between 6 ft. and 7 ft. diameter, is the smaller of those that will be employed, and yet its weight is about 7 tons. It consists of a heavy wrought-iron beam, on the under side of which are several very formidable steel teeth; above stands a vertical iron shaft, which may be about 15 ft. long, and on each end of it are attached heavy beams of timber, that serve to guide the machine in the hole it has to form in the earth.

"The drill is soon swung beneath a carriage which runs on rails high up in the shed, and is then passed to one side. As rapidly the large dredge is brought over the pit from the other side of the shed and attached to the rope. This dredge is, in fact, a gigantic iron bucket, made so as to be capable of being easily turned over, that its contents may be emptied out of the large window or opening, formed in one side of the shed for the purpose. The bottom of the dredge, however, is hinged, and opens upwards in two parts.

"The engine is again started, the dredge disappears from sight, the floor is closed, rod after rod is attached and lowered, and when the last rod is fastened the beam is again brought back to its place, and the dredging apparatus moved up and down a few times, being turned round at the same time by the capstan bar. The beam is again detached, and run on one side, the dredge is raised, and when slung underneath its carriage is pushed forward to the window, which is now opened, and by means of a rope and winch, gently turned over, discharging its contents of water and mud, broken stones and sand, into a shoot, constructed outside the shed. The mud that comes up is to a great extent sufficiently liquid to run away down the ditches, and over the adjacent grounds, and but little spoil, at present, has accumulated near to the pit-mouth.

"We have now described the work as far as it has yet been carried on. The large drill has yet to be used; this will excavate the pit to the full size of about 16 ft. diameter, but the smaller drill always precedes the larger one, and thus a small shaft is always sunk in advance of the full-sized one, the advantage of this being that the earth loosened by the action of the large drill always falls into the smaller shaft, by which it can be easily removed by the dredge.

"There is no doubt that with continued practice the laborers now employed will work with even greater precision than they do at present in handling the very heavy machines, whose motions they have to direct, but with the short discipline they have had it will certainly strike every visitor to the colliery that they work more like artillerymen at heavy gun drill than colliers—every tool seems ready to hand, every man knows his place, the work goes on silently and rapidly, the men working, no doubt, all the better from being in a dry, well-swept and well-arranged shed, rather than on a pit bank, where dirt, wet, and cold, exhaust their energies, and impede their progress."

PREVENTION OF THE CORROSION OF IRON.

PROFESSOR BARFF describes the results of a great number of experiments made by him, which, as he thinks, indicate a method of so preparing iron and iron goods that they shall not be liable to rust and consequent destruction.

The process of rusting is, as every one knows, an oxidation of iron. First the protoxide is formed, which consists of 56 parts of iron and 16 parts of oxygen, and this is rapidly converted into the sesquioxide, the proportions of which are twice 56 parts of iron and three times 16 parts of oxygen. There is another oxide of iron known as the black oxide, which consists of three times 56 parts of iron and four times 16 parts of oxygen. This oxide undergoes no change whatever in presence of moisture and atmospheric oxygen, and Professor Barff therefore believed that if it were possible to convert the surfaces of iron plates into the magnetic or black oxide of iron, in such a manner that the particles of black oxide formed in the position of the original particles of iron could be rendered perfectly adherent to the iron surface, which does not become per-oxidized, and perfectly coherent with one another, corrosion would be prevented. The best method for carrying out this process for the protection of iron articles in common use has been found to be to raise the temperature of those articles, in a suitable chamber, say to 500° Fahr., and then pass the steam from a suitable generator into this chamber, keeping the articles for five, six, or seven hours, as the case may be, at that temperature in an atmosphere of superheated steam. It is stated that a surface of the black oxide thus produced resists for a long time, and more effectually, the rubbing with emery paper, than does the simple metallic iron itself, and that there is a very manifest difference between the ease with which a sharp rasp is able to cut away the surface of the iron and the difficulty with which this black oxide is removed from the surface by the same instrument. Professor Barff believes that iron thus treated will be well adapted for use as water pipes in place of lead, for all iron used in building, thus insuring permanence for all articles of domestic use, such as saucepans, which might then be allowed to get red hot without injury, and for many other purposes. The cost of so preparing iron articles will be very trifling.

NEW COMPRESSED AIR LOCOMOTIVE.

SOME preliminary experiments are being made in the Royal Arsenal with an engine designed by Major Beaumont, R.E. At present nothing is perfected. The engine moves about slowly on the line, but little has been done beyond the proof of the feasibility of its action. The question is an important one, so that it is worthy of attention even at this stage of the experiment. As traffic increases, especially in our metropolitan districts, horse power becomes inconvenient and inadequate to meet our requirements. Tramways, doubtless, gives it increased scope, but sooner or later engine power of some form seems likely to come in much more extensively than at present. Many believe that steam locomotion on railways cannot meet our requirements, and some power will be found that is suitable for working on roads generally. Air engines have long been looked to as likely to come in, in some form. In the abstract there appear to be certain advantages possessed by air as a motive power over steam. The noise, the smoke, and dirt of ordinary steam engines make them unsuitable for running on public roads. It is well, then, to come at once to the general principle of the design before us. In a steam locomotive engine we have the elements for manufacturing our motive power, and we perform the process of manufacturing it as we go. We have our coals and our water, and we have our furnace and our boiler, with tubes for evaporation at the extraordinary rate necessary to produce the motive power we require. To run for long distances all this is necessary. For the short stages, that may be sufficient for the traffic on public roads, Major Beaumont suggests that it is preferable to have a vessel charged with the motive power—namely, compressed air in sufficient quantity to work the cylinders of a small locomotive engine at a low pressure. Major Beaumont wishes to work up to 1,000 lbs. per square inch. At present nothing like this has been done, but locomotion has been obtained with a pressure of about 200 lbs. The engine has been handed over to the Royal Laboratory department by Mr. Hay, the head of the machinery department, and has been charged with compressed air very much as if it were a gigantic Whitehead fish torpedo, by the pumping engine used for that purpose. The air is contained in iron cylinders or tubes in five rows, those of each row being connected together, and being practically one air vessel. Each row or vessel, then, can be made to work in succession on the cylinders of the engine, which happen also to be five in number for the full pressure, but for the lower pressure at present four only are used. The smallest of these works on to the next, and so on in succession on the usual compound principle, the last and largest one working at a very small pressure against the atmosphere. The engine is intended to carry a sufficient supply of air to run for perhaps ten miles, when it would be recharged by a stationary pumping engine. The pressure of each vessel must become less and less as the air is drawn off; but the next vessel can be employed to assist the working one when it becomes weak; so that until the end of the run there ought to be all the power that is required. At present it is quite premature to speak of results. In the Royal Laboratory the pumping engine has to work for about seven hours to supply the small locomotive for a run of half an hour. This, no doubt, is due in great measure to the special circumstances of the case. It does appear probable, however, that the waste of power in pumping and charging the engines will constitute an enormous and costly difficulty when the problem takes a practical shape. The carriage of a great quantity of air under compression, even though it be divided into several vessels, is again an ugly feature in the design. Safety certainly would be on the side of carrying our raw material and manufacturing our motive power, rather than carrying the entire store of it for the journey in what is liable to be so dangerous a form.—*Engineer.*

ARTIFICIAL IVORY.

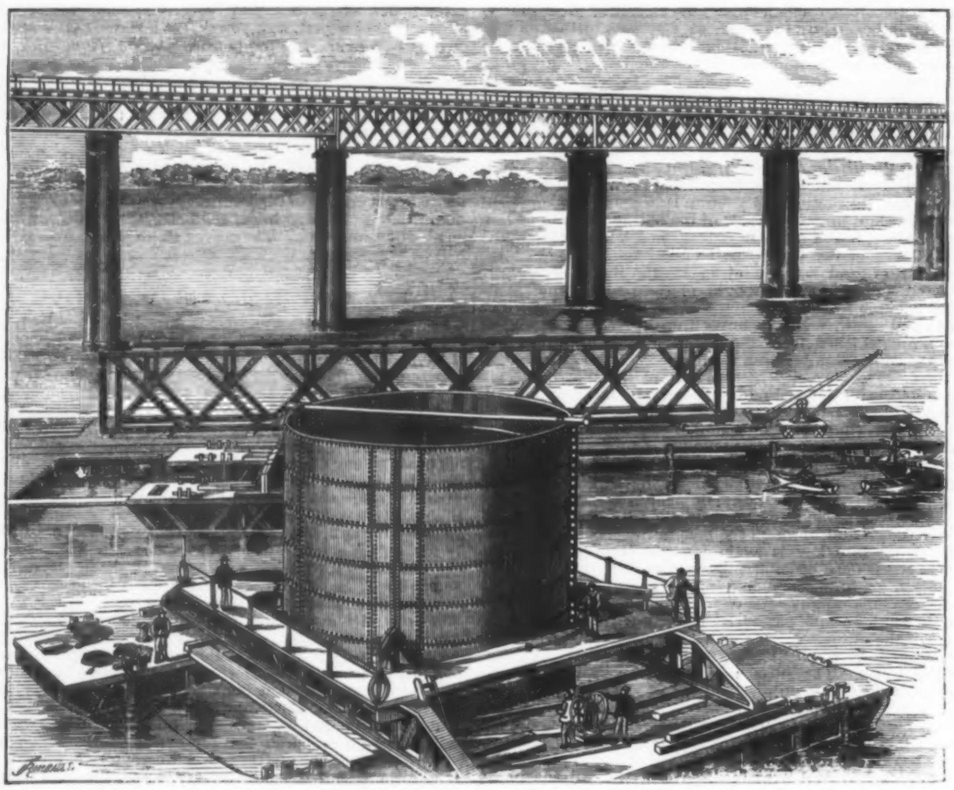
ACCORDING to *Stummer's Ingenieur*, a very good imitation of ivory may be obtained by dissolving 2 parts of caoutchouc in 36 parts of chloroform, saturating the solution with pure ammonia gas, and then distilling off the chloroform at a temperature of 85° C. The residue is then mixed with phosphate of lime or zinc-white, pressed to the required form, and dried. If phosphate of lime is added, the product has exactly the properties and appearance of natural ivory, and it may be expected to find extensive application.

DESTRUCTION OF VEGETABLE MATTER (BURLS), OCCURRING IN WOOL OR IN WOOLEN RAGS.—Michel conveys the wool upon cars sliding on a tramway into a closed chamber, heated to from 86° to 104° F., and filled with the vapor of muriatic acid. After about two or three hours the vegetable matter is found entirely dissolved, whilst the wool remains uninjured.

THE TAY BRIDGE.

The Tay Bridge near Dundee, Scotland, is the longest structure of its kind spanning a running stream. It is nearly two miles in length, or 10,321 feet, and its construction has involved the highest engineering and mechanical skill. The following particulars relating to the construction are given by E. Gilkes, C.E., in a recent number of *Engineering:*

Let us consider some of the most novel appliances and expedients which have been developed and brought to bear in its construction. The earliest of these was the sand pump, the production of which is chiefly due to Mr. Reeves and Mr. Beattie, members of the staff engaged on the bridge. These pumps draw the sand through the center of the caissons with great rapidity and ease, the caissons sinking by their own weight as the sand is removed. The process may thus be described: Upon a barge or lighter four cylindrical



THE TAY BRIDGE.—METHOD OF FLOATING CAISSONS INTO POSITION.

wrought-iron receivers are fixed, each about 5 ft. in diameter, to which are connected air pumps for exhausting, and the engines required to work them. The bottom of each receiver is fitted with a trap-door opening outwards over a hopper, and to the top is attached a flexible tube, which extends over the side and to the bottom of the hollow pier or caisson. As soon as the caisson is sunk to the bed of the river, this barge is placed alongside it, and the flexible hose being directed by divers, who at once go down inside the pier, the receivers are exhausted by the air pumps, and the sand and water rushes up the tubes to fill the vacuum. As soon as one receiver is full, the turn of a handle opens another, and the same process is repeated, the air pumps never ceasing. A small air trap destroys the vacuum in the charged vessel, and the fall of the trap-door liberates the sand, which falls into the river again, but *outside* the pier instead of *inside*. By the adoption of four receivers constant working is secured, and the rate of sinking is very rapid.

These sand pumps were used in the early history of the bridge, and their efficiency proved. They have been enlarged and applied with great success in sinking the large 31 feet caissons which form the foundations for the piers of the large spans. It will be readily seen that the combination just described is applicable to all excavations in soft material, giving a facility hitherto unattained.

The general dimensions of the sand pumps are: Diameter of cylinder, 7 in.; stroke, 12 in.; diameter of air cylinder, 12 in.; stroke, 12 in.; steam, 50 lbs.

Each tank holds 60 cubic feet, and it takes from one to three minutes to fill one tank, according to the depth.

Forty-four cubic yards per hour can be taken out with a sand barge of the foregoing dimensions with four receivers. The process is patented by its designers, and is just now being adopted on a bold scale, to transfer the sand from the bed of the Tay to the inside of the wall of the Esplanade; and thus it is proposed to fill up the large inclosed area.

The extension of the size of the caissons to 31 ft. in diameter was not a difficult matter, and naturally suggested itself as the means to secure enlarged base, with the needful solidity and strength; but the building, floating, and sinking of these large caissons was a matter of no ordinary difficulty, and required the most careful calculation, and special machinery of an original, although simple, character.

Let us begin to make, and float out, and lower, and afterwards sink, a 31 ft. caisson. We first build on shore (but within high-water line) a caisson of wrought-iron plates ⅝ in. thick, and riveted together in the ordinary way, 31 ft. in diameter and about 20 ft. deep, making the lower course of plates a wedge, by duplicating them at an angle of 30 deg., the duplicate plates being on the inside and only about 18 in. deep. We thus have a cutting edge to that part of the caisson which has to be sunk into the ground, and the same arrangement which provides this also produces a base for the brick lining 15 in. thick, which is put into this lower member of the caisson before it is floated out. A further length of 20 ft. of caisson is then built on the portion already made. This is called the temporary caisson, the other the permanent caisson, because the latter has to be left in the ground, and the former, being joined by bolts, is liberated and used again for a similar purpose. This cylinder, then, 40 ft. high and 31 ft. in diameter, the lower 20 ft., being lined with bricks, waits until the tide serves for the operation, and then is floated out to the spot where it is to be placed as the foundation rock of one of the piers of the bridge.

The floating out is an operation in which tide, time, and weather have all to be considered, and consulted, and waited for; but, supposing all these to be in accord, two large pontoons or barges, on which a strong framework of girders is placed, come alongside the caisson, the framework of girders having been previously lowered around the structure, as the water provided the power and opportunity. On the corners of these girders are fixed powerful hydraulic rams, and from these, levers take hold of the caisson at four points by T-irons, which are riveted to it, the webs being perforated with holes 2½ in. in diameter, and 12 in. center and center. As the tide rises, the pontoons lifting the whole combined arrangement, the caisson hangs suspended by the four levers pinned to the T-irons by steel pins, which are carried by the four hydraulic rams, which in their turn are attached to, and stand upon, the corners of the framework of the girders, which are borne up by the pontoons. So the whole fabric rises with the tide, and at high water is towed out to the position which the caisson has to occupy as part of the bridge. Here it is anchored, *above* the line which it must ultimately take. Then at ebb tide the hawsers are slacked, and the caisson is floated down to its exact place on the center line of the bridge. Meantime the lowering process has commenced. The levers, which held the caisson in suspension, have been alternately raised and lowered by the hydraulic rams; and, by an arrangement of steel pins, the caisson, caught by the levers at their highest elevation, is held by them until the ram has lowered them 1 ft., when it is supported by other steel pins, which carry it until the levers are replaced, the weight again resumed by them, and again lowered by the depression of the hydraulic ram, which was raised to its full lift of 1 ft. in order to bring the lever again into position. Thus the caisson, weighing upwards of 200 tons, is lowered with ease and safety, at the rate of about 5 ft. per hour, and ultimately rests on the bed of the river. The last 12 in. or 18 in. are of course of the utmost importance, so, before the caisson is finally lowered, its position is confirmed, both as to the center line of the bridge and its distance from the last pier, and thus, one by one, have these large masses of wrought iron and brickwork, which, as they cross the river, look like huge castles, been successfully placed as integral parts of the great whole, which will, when finished, be the Tay Bridge. So soon as the caisson is in position, it becomes needful to protect it from the scour of the water. This is done by quickly depositing rubble round its base. Immediately the sand barges before mentioned are brought alongside, and divers go down into the center, and slowly and steadily the huge hollow castle sinks into the ground as its foundation is sucked from beneath it. This done, the caisson sinks down to the required depth, the center is filled with cement concrete, when we have a large and artificial rock on which we proceed to build the pier.

Here, again, new applications of old ideas have been introduced into the practice at the Tay Bridge. The piers which rise from the bed of the river to high-water line are of a hexagonal shape, 27 ft. long and 16 ft. broad, the length of course lining with the current of the river. The center of the brickwork is left hollow in building it. This is done on shore to a height of about 20 ft. to 22 ft., which is sufficient to reach from the top of the caisson or the bed of the river to the low-water line. After due time being allowed for the pier thus built to set and become solid, it is framed with suspension girders in a similar manner to that adopted with the caisson, suspended by levers with hydraulic rams, lifted by barges and tidal action, towed out, anchored, centered, and lowered, and thus at one leap the pier rises from the river bed to low-water line. The center of this block of brickwork is then filled with cement concrete, and the whole mass becomes one solid stone.

The erection of the brick pier from low-water line to high-water line is, of course, a succession of tidal operations. So soon as the top of the pier is bare, barges are surrounding it, and busy hands are laying bricks in cement, being supplied with every material, and all manual and mechanical aid that can enable them to produce the utmost actual finished work in the tide; and thus the pier is grown, tide by tide, until it crops above the high-water line, and, when capped with stone, is ready to receive the superstructure of compound cast and wrought iron pier, which is to be placed upon it, and upon which the girders have to find their rest.

We come now to another application of mechanical forces, and another use of natural forces, in the placing and raising of the large girders. And here we may note that the processes, described as used for the 245 ft. spans, are equally applicable to the smaller spans, and have been, according to their requirements, used for them.

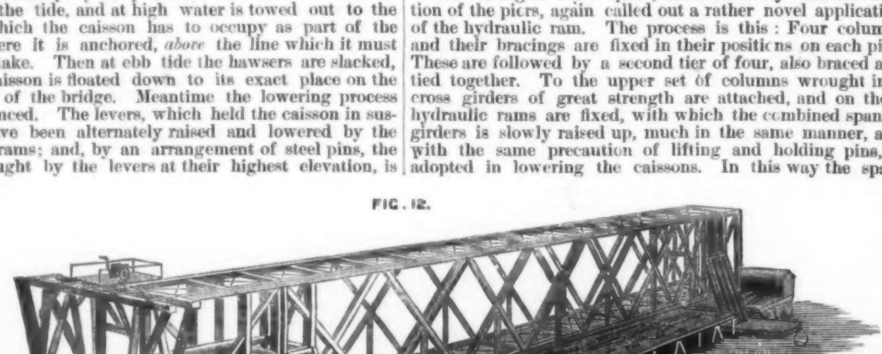
The girders are all made in detail and put together at Middlesbrough, then shipped to the Tay and unloaded at the wharf, which is on the Fife side of the river. Here there is a considerable cluster of workshops, foundries, etc., together with the needful offices for carrying on such a work (on which at the present time from 500 to 600 men are engaged), and here the girders are reconstructed on a platform over the water. In passing, we may notice that a Roots' blower is used to supply the blast to the rivet fires, and these are portable, and made of very easy application by the conveyance of the blast to them through large tubes of india rubber.

The girder when built, or, let us say, one entire 245 feet span, consisting of the two main girders, the cross-bearing girders (which, in these large spans, are of wrought iron), and the tie girders overhead, weighs upwards of 200 tons. When it is complete and ready for transference, two pieces of the platform are removed, and pontoons floated into their places. As the tide rises, the whole structure, a complete span, is lifted up until it is clear of the platform. At high water it is towed out, and, with the same precaution as to anchorage, placing, etc., it is left by the pontoons, which go with the receding tide, on the tops of the piers, ready for being elevated to the upper level of the bridge. The operation of floating out occupies three-quarters of an hour when the weather is fair and the surrounding circumstances propitious.

The raising of these spans, simultaneously with the erection of the piers, again called out a rather novel application of the hydraulic ram. The process is this: Four columns and their bracings are fixed in their positions on each pier. These are followed by a second tier of four, also braced and tied together. To the upper set of columns wrought iron cross girders of great strength are attached, and on these hydraulic rams are fixed, with which the combined span of girders is slowly raised up, much in the same manner, and with the same precaution of lifting and holding pins, as adopted in lowering the caissons. In this way the span, weighing about 200 tons, is lifted up as the piers are built—the final lift being given from extra columns that overtop the whole structure of the pier. After the girders are at their greatest elevation, the cutwater columns are erected and braced to the others, and the whole pier is consolidated and completed, the girders being at the same time settled in their final position. The apparatus for lifting girders, hydraulic rams, etc., is then removed to another pier. This process has been successfully carried out in several of the spans already, and it is hoped that the same exemption from accident or failure may continue.

A consideration of the action of the wind on this bridge will dissipate the often advanced theory that at some period it will be blown over. The exposed surface of one large pier

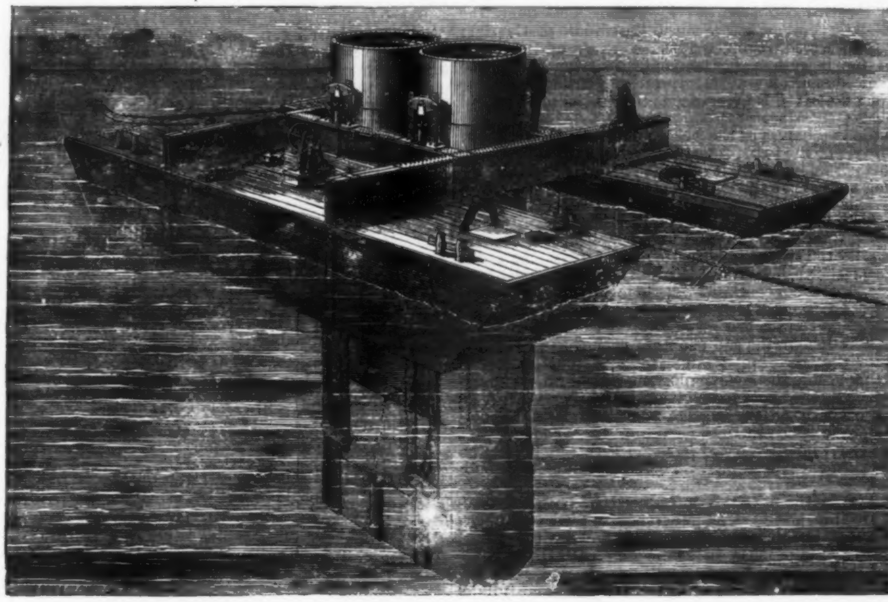
FIG. 12.



THE TAY BRIDGE.—FLOATING THE LARGE GIRDERS INTO POSITION.

is about 800 square feet, and, of the superstructure which depends upon it about 800 more, and, so giving 800 ft. for a train above, we have 2,400 ft.: 21 lbs. per square foot is the force of a very strong gale, but it would take no less than 96 lbs. per square foot on the surface given to overturn the pier. Even the most severe hurricane on record would equal only one-half this resistant power.

We have now followed the caissons, the girders, and the piers to completion. Let us look at a few of the accessories. In the whole work there is an extensive use of divers, and the most advanced appliances have been called into requisition. Each diver is furnished with a lamp, the flame of which is supported by air which is admitted to it by a self-acting valve between the lamp and the air inclosing case around the diver's body. He is thus able to see his work below the surface, and can do much more work in loosening bolts, etc., than he could do in the dark. Again, it is desirable that there should

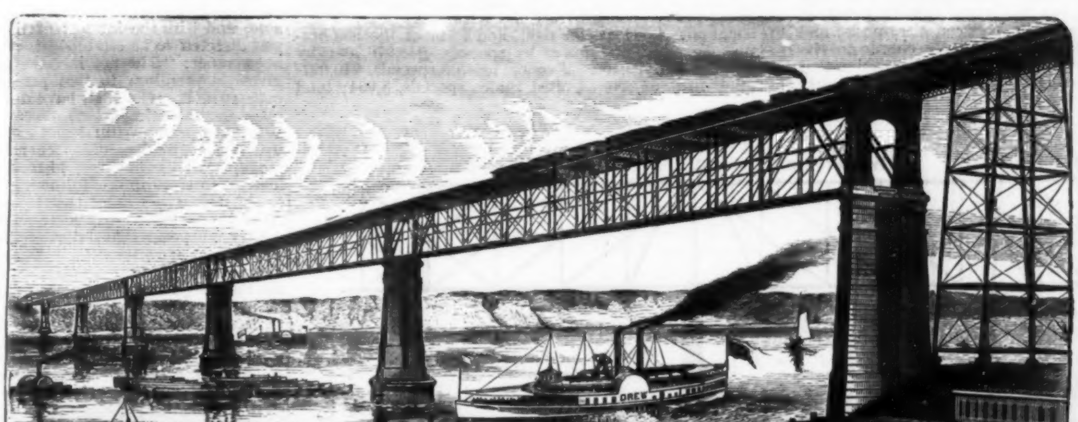


THE TAY BRIDGE.—MOVING THE CAISSONS.

be easy communication with the diver, and this is now secured by a speaking tube attached to his helmet. The waves of sound impinge on a delicate diaphragm inside the helmet, and are thus conveyed to the diver's ear. His answers are spoken into the helmet, and reach the ears of the upper listeners like the faint halloo of a man calling at a distance in a thick fog. At a moderate depth, say 50 feet, a diver can continue under the water any length of time—food, etc., being the only necessities that need bring him to the surface. The usual length of a diver's day is eight hours, during which he comes to the surface two or three times. The plant required for the work is varied and subject to much hardship. Four steamers are always in use, a large one to tow and do the heavy work, a steam yacht which tows the barges in and out, a small quick-running steamer to take the men out to their work at the different piers, and a steam wherry to keep the barges lying at the piers supplied with bricks, sand, and cement. Add to these barges of all sizes, and a fleet of small boats, and it will not be matter of wonder that a constant staff of boat builders is required for repairs. The cement used is an important item in the cost, and also in the value of the work; the proportions are one of cement to one of sand, and the pure cement is tested with great care, the requirements of a quick setting and yet a very strong cement being not always found together. It is only fair to say that the cement manufactured by Messrs. Martin Cohn & Co., of Newcastle, has proved itself admirably suited to the purpose, and equal to all the requirements.

The latest scientific appliance which has been adopted at this work is the electric light. In order to complete the bridge by the 1st of September, 1877 (which is the date to which the wishes of the company, and the hopes of the contractors point), it became needful to adopt some mode of lighting the yard when the girders are being put together, so that during the dark evenings and nights of the coming winter the work could be proceeded with uninterruptedly. This result has been secured by the introduction of two of Gramme's electro-magnetic machines, which are fixed in a building close to the foundry engine and driven from it. They required about four horse power to work them. The electric current so generated is conveyed through insulated wires to two of Serrin's lamps, which are fixed in sentry boxes on the top of the hill overlooking the works. The lamps are of simple construction, the light being produced by passing the current through carbon points, one positive and the other negative. The points are kept about ⅛ in. apart, and become incandescent, burning slowly, but with a most brilliant light. When the carbon points have burnt away so much that they are too far apart, the current of electricity ceases to pass, but is diverted from its course and gives motion to some ingenious clockwork, which brings down the positive pole, and renews the connection, so that the current at once resumes its former course. The points meet in the center of a parabolic reflector, and each of these lamps gives the light of 1,000 candles. Together they so illuminate the yard and the surrounding district that work can proceed with nearly the same ease as in the daytime, and on a dark night you can read the time on a watch at nearly two miles distance. The best results are confidently expected from this comparatively new application of the electric light.

In conclusion, the writer would remark that he has in this narrative of the progress of this, the largest bridge in the world at present, sought only to give the most salient and interesting particulars, and to give these in as plain and simple a manner as possible. The work will undoubtedly be a great work when completed. It has many difficulties connected with it which are not common to bridge building, and these have been met as they have arisen by new schemes, or new applications of old ones. The success which has so far attended the undertaking is owing, in a large measure, to the cordial earnest working together of all—the engineer-in-chief, the resident engineer, and the active staff. Each member of this group of co-workers has made it a matter personal to himself, and the Tay Bridge, when completed, will be a great example of the strength of unity, both in itself and in those by whom it was designed and constructed.



THE NEW RAILWAY BRIDGE OVER THE HUDSON RIVER, AT POUGHKEEPSIE, N. Y.

THE NEW RAILWAY BRIDGE OVER THE HUDSON RIVER, AT POUGHKEEPSIE, N. Y.

OUR engraving illustrates the intended form and general appearance of this great work, which is now in process of construction by the American Bridge Company.

The contract is for $3,050,000 cash, or $3,412,000 payable $1,000,000 in cash and the balance in bonds.

Soundings and borings have been made, the results showing that a good foundation can be had only by going to the hard gravel, overlying the bedrock, at a depth of about 100 feet for the west pier, and about 120 for the east pier. For the two center piers good foundations are obtained on hard compact clay, at a depth of 80 feet. The depth of water is from 50 to 60 feet. The material through which it is necessary to sink the foundations is from 40 to 70 feet in depth, composed of silt, mud and sandy clay, free from large stones.

The caisson for the east and west piers will be 100 feet long and 50 feet wide, allowing a pressure of 3·5 tons per square foot of base. The caisson for the two center piers will be 60 feet wide and 100 feet long, allowing three tons pressure per square foot of base, with maximum load of pier and bridge.

The caissons will be built of yellow pine and hemlock timber, framed and bolted together, and divided into 40 compartments by four longitudinal and seven transverse partitions, three feet in thickness. Twelve of these compartments, 12 feet square, are open at the bottom, and through these the material is to be excavated. The outer and center compartments are closed at the bottom by timber built solid for a depth of 15 feet, and framed to form a wedge-shaped cutting edge at the base. The cross partitions only extend to a point four feet above the cutting edges. The closed compartments resting on the cutting edges, which are shod with iron, carry the weight required to sink the caisson to place.

All compartments are to be filled with concrete, after the caissons are sunk to place, up to a point 25 feet below the water line, where the cut or coursed masonry will commence. There will be required in each caisson about 1,200,000 feet of pine and hemlock, 120 tons of iron, wrought and cast, and 10,000 cubic yards of concrete.

There is now under contract for delivery at Poughkeepsie 4,000,000 feet (board measure) of pine and hemlock, 1,000,000 of which is now delivered and 400,000 framed and in caisson.

The first caisson, designed for the first pier, will be floated to position by April, and will be ready to receive the masonry early in May. The second one will be put in position during the month of May, and the third and fourth immediately thereafter.

The American Bridge Company is one of the most enterprising concerns. Their exhibits at the late Centennial were very striking. Among them was a model of the bridge which they are now constructing across the Monongahela River at Pittsburgh. It is a stiffened chain bridge with a center span of 800 feet, the first long span example of its kind. It is proportioned for a moving load of 1,600 pounds per lineal foot, and is expected to be finished very soon. There were also models of an iron pier as built for the bridges over the Missouri River at Leavenworth, Kan., and Boonville, Mo., and of a stone pier sunk upon a wooden caisson by the pneumatic process at various localities. This company is fully equipped for building pneumatic substructures, and have built such foundations all over the country with great and unvarying success. The address is The American Bridge Company, 310 La Salle street, Chicago, and 20 Nassau street, New York City.

VALUABLE REFUSE.

ON the recent closing up of the Smith & Rogers' silver-plating concern in New Haven, on its removal to Meriden, the floor of the plating-room was taken up, burned, and the ashes analyzed, with the result of procuring pure silver to the amount of $981. This result is not so strange as appears at first sight. The precious metals are capable of extreme volatilization under heat, becoming mere vapors, which may be condensed, resulting in the production of the metal in a pure form. But, even without heat, the particles of gold and silver are made so exceedingly fine in the processes of the manufacture of gold and silver goods, whether solid or plated, that no devices for saving the material abraded or thrown off in the various manipulations are entirely effectual. Even in the Government assay offices the soot deposited in the chimneys from the melting of the crude metal is valuable; and in most manufactories of articles of gold and silver the proprietors do not allow the workmen to retain their work clothes when worn out, but pay for them a price generally sufficient to procure new garments—an old tattered vest belonging to a bench workman sometimes being valued by his employers, even when worn to rags, at $20.—*Hartford (Conn.) Times.*

A NEW ELECTRIC DEVICE FOR REGULATING CLOCKS.—English journals describe a new and simple electric regulator recently put on the clock at the Bankers' Clearing House in London. A quadrant of a circle is cut through the figure XII., the centre being above the quadrant. Through this project two studs, suspended from the centre of the circle by two levers, which ordinarily hang wide apart, one at two minutes to and one at two minutes past the hour, both free of the minute hand, but so attached to the armature of an electro-magnet that they fall down sharply when connection is made, and meet exactly at XII. They are long enough to engage the minute hand, and will do so every hour.

A LOCOMOTIVE engineer, who had just been discharged for some cause, gave vent to his spite by saying that it was about time he left the company anyhow, for the sake of his life, for "there was nothing left of the track but two streaks of rust and the right of way."

THE KENTUCKY RIVER BRIDGE.

About twenty-three years ago, the late John A. Roebling commenced a work, which, if completed, would have been the crowning triumph of his life. It was a railroad suspension bridge of 1,236 ft. span, crossing the canon of the Kentucky River 275 feet above the bottom of the gorge. The towers were built and the anchorages finished, but at this stage of the work the railroad company failed. Roebling was stopped, and until the engineers of the Cincinnati Southern Railway decided that no better crossing than at Roebling's location could be found, the giant piers stood in a deserted wilderness, a monument to the financial crash of 1857.

When Cincinnati decided to build a railroad to Chattanooga, the gorge of the Kentucky was found to be one of the worst obstacles on the route; and when bids on this crossing was called for, each competitor was required to make up his own plan for the entire structure, which plan it was obligatory should meet the difficulties attendant upon the following conditions of the case: First, the erection of a structure over a chasm 275 feet deep; next, in connection with this the fact that the rise and fall of the river was 55 feet, and that it had been known to rise 40 feet in a single night and generally averaged a flood every two months. Lastly, the river makes a bend just under the bridge, which renders its passage by steamers and rafts too hazardous to permit of the erection of a pier in the waterway.

A number of meritorious plans were presented, but the one finally accepted was that prepared by Mr. Shaler Smith, of the Baltimore Bridge Company. The viaduct as now being constructed consists of three spans 375 feet each, resting

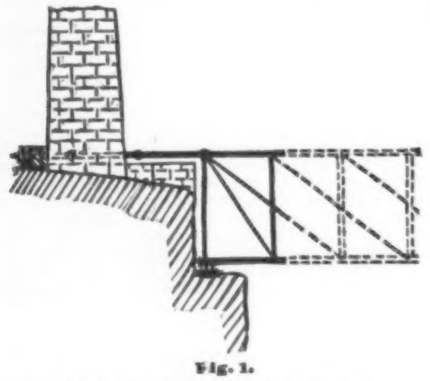


Fig. 1.

THE KENTUCKY RIVER BRIDGE.

on the bluffs and on two iron piers, which latter in turn are supported by stone piers, each 120 feet long by 42 feet in width at the base. The iron piers consist of four legs each, and while having a base of 71 ft. 6 in. by 28 ft., their longitudinal profile terminates in a point at the top, or rather in a 12-inch pin upon which the truss rests as on a rocker. The entire pier is a complete structure within itself and can be rolled about on the masonry, the pedestals resting on double roller beds for this purpose.

The truss itself is, during erection, a continuous girder of the Whipple type; but after erection it will be converted into one continuous girder 525 ft. long, projecting at each end 75 ft. over its points of support, and carrying from each of these cantilevers a 300-feet span, which bridges the distance from the end of the cantilever to the bluff. It was necessary to make the bridge a continuous girder in order to raise it without false-work; and the hinges were obligatory because the rise and fall of the piers from thermal changes will amount to fully two inches, and would vary the strains hourly in a true continuous truss. The truss is 37·5 ft. deep and 18 ft. wide, and each bay is divided into 20 panels of 18·75 feet each. All connections between ties, posts, and chords are hinged on pin connections, but the chords are riveted to each other throughout, with the novel addition that the pin carrying the tie bars is forced into the chord splice by hydraulic pressure, and thus does duty as a rivet. It will be seen that the details combine both the American principles of pin joints and of massing the materials in approved shapes along the lines of strain, together with the European practice of continuous riveted chords fitted to resist both tension and compression. This peculiar mode of construction was adopted in order to erect the truss in the manner which we are now about to describe.

After the bridge seat was cut out of the cliff, the end posts were set up and the first section of bottom chord laid in place, each cord being continued back to the rock by a large screw-jack placed between its rear end and the face of the bluff. Then the top of each end post was bolted back to Roebling's towers by anchor bolts, which had a screw adjustment. From this point the end or main tie was carried to the bottom chord at the foot of the second post, and then post No. 2 and the first panel of top chord were put in place. When the first panel was in position the work looked as shown in Fig. 1. It will readily be seen that with these connections once made the structure could be built out panel by panel until the limit of strength of the anchorage bolts or of the top chord or the available resistance of the Roebling towers had been reached. This last was the governing factor, and the other parts were proportioned to suit. Accordingly, as the truss grew out from the face of the bluff a temporary wooden tower sprang up from the bottom of the valley to meet it, the centre of the tower being 196 ft. 10 in. from the shore end of the span. When the truss was landed on the tower, the four truss posts resting on it were raised by large jack-screws until the anchor bolts were relieved of a previously determined portion of their strain, and when this point was reached the work of carrying out the span was again commenced.

The next flight was to the permanent pier, 178 ft. 2 in. When the span left the bluff the iron pier was started upward from the masonry, and the two met in mid-air, the working forces on each arriving at the point of junction within two hours of each other. The weather was cold, and the span was short, owing to the compression of the lower chord and the effect of the temperature; but this had been foreseen, and the huge pier, weighing 400,000 lbs., was moved on its rollers toward the span until the pier which connects the two could be put in place. This done, the truss was built out as before until the middle of the river was reached, which completed the work from the north side. In the meantime the temporary wooden tower had been taken down, and at this present writing the same process just described is going on, but from the south side of the river.

When the two halves of the bridge meet, in the centre of the middle span, the two projecting half spans will be adjusted to the same level by loading the shore spans, and the connecting sections of chord put in place. The last operation will consist in taking out the bottom chord pins in the fourth panel north and south of each pier in the shore spans, thus hinging these two spans and fixing arbitrarily and without ambiguity the strains in all parts of the truss. In order that there may be no doubtful action at the hinging points, both web systems are concentrated into one in the two panels adjoining the post at which the chord is cut, as shown in Fig. 2.

This is also done in the end panels of each span in order to concentrate the shearing strains more conveniently. In erecting this bridge the most important points for computation were: first, the angle to be given the span at starting so as to land properly on the wooden pier; and, next, the correct elevation to be given to the truss at the wooden tower so that an exact junction could be made with the pin on the top of the permanent iron pier. These operations were both successful.

Altogether, in the novelties introduced in both construction and erection, and in strict adherence to theory throughout, this great viaduct—the most important in the world in regard to length of span in connection with its height—is probably unsurpassed by any similar work now existing. When it is completed we hope to publish a plate and full description.

The engineers who decided upon Mr. Shaler Smith's design as the best were Mr. Thomas D. Lovett, then Consulting Engineer of the Cincinnati Southern, and Mr. G. Bouscaren, who has since succeded him in that position. The iron work was all done by the Edgemoor Iron Company, and it was watched and inspected from the rolling mill pile to the finished bridge, pieces being tested out of every plate used. The modulus of elasticity was obtained for every individual eye-bar, and the bars were paired together according to their moduli. Messrs. C. C. Wrenshall, Charles Houser, and Michael Walsh are the superintendents in charge of the erection, and the engineers on the part of the railroad company are Messrs. Rudolph Weiser, Charles Lasker, and Charles Bates. The erection was begun on Oct. 16 and will probably be completed about Feb. 20. There are 2,855,000 lbs. of iron in the spans, and 798,000 lbs. in the piers, and the amount of masonry is 12,915 cubic yards. The spans have iron stringers as well as floor beams—*Railroad Gazette.*

Fig. 2.

THE KENTUCKY RIVER BRIDGE.

THE FIRES OF 1876.

A total of 9,301 fires is summed up by the the *Chronicle* from its monthly records of fire losses in the United States and Canada during the year 1876, being an average of nearly 25¼ fires per day—a slight fraction over one per hour. These fires embrace 4,586 special risks, and 4,715 of the less hazardous classes. Total losses by specials, $45,976,700; by other risks, $27,799,100. Average loss on specials, $10,027; by other fires, $5,896. United States specials, 3,954; total loss, $42,204,400—average, $10,675. Canada specials, 632; total loss, $3,772,300—average, $5,969. High as these averages are, they yet fall short of the table for 1875. In that table the number of total fires was not given—only the number of specials, viz.: United States, 3,203; average loss, $15,720. Canada, 459; average loss, $10,947. This comparison shows a more numerous *occurrence* of fires in 1876, with lower rating of amount lost, and this may have come from less amount of stock on hand (in a comparatively nonproductive period), or from lower pricing; either or both. The total loss of 1876 is put down at $73,775,800, against $86,328,035 the previous year—the United States decreasing $13,471,685, Canada increasing $919,450. It is possible, if all the collateral data were at hand, that there might be shown a greater amount of actual substance destroyed in the United States by fire in 1876 than in 1875. The *Chronicle*, however, suggests the fires of Nevada and Oshkosh as explanation of much of the greater amount of 1875. To this we will add, that only one United States fire of 1876 approached three millions of dollars, and no other in the United States reached one million.

Two fires of 1876 in the Dominion of Canada burned 900 houses, involving a loss of $2,500,000, and another took a million and a half. These three fires make nearly one half of the total Canada loss—the Dominion otherwise not burning up to its average; conspicuously this was the case with regard to specials. By the tables we have the following ratios of insurance loss to fire loss:

UNITED STATES.

	General Loss.	Loss on Specials.
1875	50·36 per cent.	50·66 per cent.
1876	53·19 per cent.	51·37 per cent.

CANADA.

1875	52·36 per cent.	50·69 per cent.
1876	12·55 per cent.	44·09 per cent.

The influence of the three great conflagrations occurring in the Dominion is shown in the percentages for 1876, the companies not sustaining the normal ratio of loss at such fires.

Specials burning in 1876 present little marked contrast with those burning in 1875—those that burn most in one year burn most in another as a rule, and, this generation out, the number on fire will depend upon the number in existence, or rather in operation. The 4,586 special risks burned in 1876 were of 521 kinds, and of these kinds 19 embraced more than one half of the single risks, viz., 2,409. The following are the numbers of these 19 kinds of specials burned in the United States and Canada in 1876, arranged as to total risks burned in both countries:

Order of burning 1875		United States.	Canada.
(1)	Hotels	318	72
	*Country grocery stores	214	83
(2)	Saw mills	167	48
(4)	Drug stores	145	21
(5)	Restaurants	153	7
(3)	Liquor stores	145	14
(6)	Livery stables	118	17
	†Cotton-gin houses	99	..
(12)	Carpenter shops	78	25
(7)	Furniture factories	82	20
(9)	Flouring mills	77	10
(10)	Churches	66	13
(15)	Carriage factories	49	25
(16)	Bakeries	49	16
(14)	Blacksmith shops	47	17
(11)	Planing mills	59	3
	*Ice houses	53	2
(13)	Lumber yards	52	7
(8)	Machine shops	53	4
		2,025	384

Number burned is, of course, no index to aggregate value lost. Among those numerically greatest as to the breaking out of fires are those which involve small ratio of destruction. Possibly our contemporary may add to the value of its service in this line by tabulating the amount lost on each class of specials.

The insurance losses, as distributed among the respective States, will be substantially confirmed by the reports of the State Insurance Departments. The teaching of such tabulation, with the deductions from the collateral data, will perhaps determine whether Massachusetts, Michigan, Illinois, California, and Texas are not the greatest fire States, in respect to proportion of combustible values in the country.—*Amer. Exch. and Review.*

* Not reported in list of 1875. † Not fully reported in 1875.

THE BRESSA PRIZE.

By the will of Cesara Alessandro Bressa, Doctor in Medicine and Surgery, signed the 4th of December, 1835, that gentleman left all his property, after paying certain legacies, in remainder expectant on the expiration of a life interest, to the Royal Academy of Turin, with power to convert and put the capital out to interest in the way deemed most profitable; and with the interest of this property a biennial prize was directed to be established, and adjudged in the following manner: "The net interest of the first two years to be given in premium to that person, of whatever nation or country he be, who shall have during the previous four years made the most important discovery, or published the most valuable work on natural and experimental philosophy, natural history, mathematics, chemistry, physiology, and pathology, as well as geology, history, geography, and statistics. The net interest of the following two years to be given only to an Italian, who, by the judgment of the above-named Academy of Turin, shall have made the most important discovery or have published the most important work on any of the above-mentioned sciences. The prize will continue to be distributed in the same order." The Academy has accepted the task, with the intention of fulfilling to the best of their ability the generous wishes of the testator, and the first open prize will be given in the year 1879. The value amounts to 12,000 Italian lire, or about £370 sterling. In accordance with the spirit of Dr. Bressa's will, the Academy will choose the best work or discovery, whether or not it be presented by the author. The prize in no case will be given to any of the national members of the Academy of Turin, resident or nonresident. In the year 1881 the second Bressa Prize will be given for the preceding quadrennial term 1877–1880, according to the above rules, to an Italian. And so on every four years there will be a Bressa Prize for competition among scientific men of any part of the world, and every four years a Bressa Prize which can be competed for by Italians only.

PREVENTING CLOUDINESS ON EXPLORING MIRRORS.

By Dr. Sanundes.

Consists of passing lightly over the mirror a cloth steeped in glycerin. The watery vapor contained in the expired air is dissolved completely in the glycerine, and the cloud does not form. He proposes the extension of all glass and optical instruments liable to become obscured by cloudiness.

TEMPERING GLASS.

Herr Pieper has devised a method of tempering and hardening glass, which is so far successful that the German glass-makers are said to have given 15,000*l.* for the exclusive right to use it in their country. The new process consists of submitting the glass, while at a red heat, to the action of superheated steam.

BEST FLOOR FOR STABLE.

AN Orleans County correspondent of the *Tribune* is about building a stable, and desires to make a box stall for horse, and is in doubt as to what kind of floor to use. Has thought of paving the floor and filling in between the paving either with gravel or grout of water lime, and so constructing the bottom as to carry off all liquid deposits, but does not know whether such a floor would make a good one for the horse to stand upon, and asks advice. A floor laid with paving stones or hard burned brick, set on edge and filled in the intervals with water lime will prove quite satisfactory for animals kept constantly shod. Among the most essential points to be secured are cleanliness, impermeability to moisture, and the means of securing a good foothold. Soft porous brick will not only wear too fast, but will absorb putrid liquids and gases, and will be a permanent source of foulness and impure air. Some porous stones are equally objectionable, and brick and stone containing common salt are very pernicious, as being liable to draw water and prove cold and unwholesome. Hard non-absorbent brick is decidedly preferable to stone as being warmer; but if soft and porous the lodgment given to putrefying liquids will more than counterbalance its advantages. So with regard to wooden floors, which, although warm, are positively injurious as receptacles of filth, which, added to their own speedy decomposition, contribute greatly to atmospheric impurity. In the case of feet that are treated, tender, or divested of their superficial layer of horn by the file, these floors contribute much to drying, shrinkage, and contraction. If the feet alone were to be considered, an earth floor would be preferable, but as this speedily absorbs much decomposing material and becomes a reeking mass of impurity, it is better on the whole to secure a well drained impervious floor, and rather use a hoof ointment if necessary to palliate any acquired weakness or disorder of the feet. For a floor, on which an animal may stand unshod when necessary, brick will prove suitable, or paving stones having a flat rather than a rounded surface. Though perfect drainage must be sought, a too great slope should be avoided, and a fall of two inches may be looked upon as a maximum.—[James Law, Cornell University.]—*N. Y. Tribune.*

PLAN FOR A SMALL VEGETABLE HOUSE.

A CORRESPONDENT asks the following in the *Gardener's Monthly*:

"I purpose to put up a small greenhouse, and am ignorant of the best plan to build one; and would like to ask you if the following plan is a good one.

"I think about 21 feet by 10 feet would be large enough. I purpose to dig it out the above size, and wall up with boards, about two feet above the ground; and have the middle of the roof about two feet higher than the sides; with a cistern for water, about eight feet square, and three feet deep.

"Now, should the cellar for the furnace be five or six feet below the floor of the house, or that depth from the top of the ground? What size glass is best for the sash? Is one foot fall enough for the roof, or would more be better? Would it do to have a coal-stove in the house, instead of a furnace? As I wish to grow only vegetables for early marketing; commencing to fire about February 1st. Will you give me your idea on the above, or give me your plan for the purpose?"

To which Mr. W. T. Bell replies:

"If I wished to build a vegetable house of the size you mention, I would make it on the surface of the ground; boarding up the sides with rough, cheap lumber, nailed to posts set into the ground, and bank up with earth nearly to the eaves.

"This would make a warm house, and it would be drier than if excavated. If you have no shed at the end of your building, and do not need a cellar in connection with your greenhouse, dig a pit at one corner of the house, outside, large enough to give room to work your fire, put a roof over the pit, and proceed to make your furnace and flue as mentioned in the article you refer to.

"If you expect to use a fuel that will not choke the flue, build the flue along one side of the house, across the end, and return along the other side, to the chimney. Have door to greenhouse, in end, directly under the comb of the roof; and benches along each side, with a narrow space at back of bench, to allow the warm air to pass up behind the bench. The sash should be made not less than 1½ inches thick, without cross bars, except at top and bottom, and should be painted before being glazed.

"Double-strength glass is the cheapest to use; which should be bedded in putty, and securely fastened with large glaziers' tacks. Glass 8x10 inches is a good size to use, placing the long way of the glass with the long way of the sash. The slope of the roof should be not less than what carpenters call a quarter pitch, to carry off the water properly.

"If you are well supplied with water on your premises, I would not make a cistern in greenhouse, as a barrel of water standing under one of your benches would last you two or three days. A coal stove in your greenhouse would not prove satisfactory.

VEGETABLE DIGESTION.

PROF. E. MORREN of Liége, in a communication to the Royal Academy of Belgium, fully examines all the evidence bearing upon vegetable digestion, of which, it may be observed, he is an ardent supporter. He treats more particularly of the *rôle* of ferments in the nutrition of plants. It is indubitably proved, he states, that certain plants have the power of attracting, retaining, killing, dissolving, and absorbing insects, and even higher animals. Moreover, digestion is not exclusively confined to carnivorous plants, but it is common to them all, and appears to be the necessary condition to assimilation. He endeavors to show that the presence of the same organic products in plants and animals is easily explained when we recognize the fact that nutrition is similar in the two kingdoms. Formic acid, for instance, is found in ants, and in the hairs of the sting-nettle; butyric acid in sweat and in the pulp of tamarinds; palmic acid in animal fats and in palm sugar; oxalic acid in the renal secretion, and in almost all plants. The protoplasm again offers the same essential characters in plants and animals, suffers the same reactions, the same movements, and the same contractility. Basing his argument upon these and other data, Prof. Morren finds nothing remarkable in a similarity of functions; and the facts that have been brought to light concerning "carnivorous plants" may be regarded, apart from the peculiar structure of the plants, as particular cases in a general rule.

ACRIDIUM AMERICANUM.

Two correspondents of the Department of Agriculture, writing from Vevay, Indiana, about the middle of last November, reported the visitation in that place of an immense cloud of grasshoppers that literally covered the streets of the town. One of the gentlemen observed, about five P.M., dense cumulo-stratus clouds in the southwest, gradually overspreading the sky; at six o'clock the wind had risen to moderate gusts, and within half an hour a rattling noise was heard against the windows, like that of light hail. On opening the doors, grasshoppers entered in immense numbers, covering the floors, furniture, clothing, etc. The shower continued till eight o'clock, P.M., when the ground was thickly covered, and the boys began to burn them, shoveling them into bonfires. The specimen sent shows the insect to have been the *Acridium* (*Cyrtacanthacris*) *americanum*, one of our largest American grasshoppers, and more than twice as large as either the *C. spretus* or *C. femur-rubrum*.

These same insects were so plentiful in Suffolk county, Virginia, about three years ago, that some of the farmers became greatly alarmed at their presence, supposing them to be the true migratory species. They ate up all kinds of farm produce and then commenced on the trees. The species was determined by scores of specimens sent us for examination. The insects are numerous in this locality, but, with the two instances above cited, we have not known of their coming in such swarms before.—*C. R. D., in Field and Forest.*

THE BONANZA.

UNDER the heading of "$1,080,000," the Virginia *Enterprise* of the 8th February, says: "This is the California mine dividend day. During the month its shipments have been over $1,600,000, so there is no doubt about the dividend. We wonder if one in a thousand who reads the brief announcement every month on a certain day, that a certain mine has paid a dividend of $1,080,000, has the slightest idea of what is necessary to be done in order to make such an announcement possible? Every one who ever owed a note in a bank knows that 30 days is a very brief period of time. To cause a mine to produce $60,0 0 in a single day is a tremendous feat; to continue this product daily through weeks and months, almost without variation, is a marvel. It takes forethought, endurance, judgment, and nice calculation, such as very few men possess in this world. The ore from which this mighty yield is extracted lies hid away almost a third of a mile below the earth's surface. It lies where consuming heat and baffling waters join their forces to try and drive away the invading miner. While the ore is being hoisted, every month 1,250,000 feet of lumber has to be lowered and put in position, to keep safe the weakening caused by the mighty excavations. While one level is being worked another has to be explored, for a drain of 500 tons of ore per day would soon level a mountain down. Then the Comstock is an uneasy fissure. In a single week, sometimes the swell of the ground shivers into splinters 14-inch square timbers. Shafts and drifts and inclines and tracks have to be watched incessantly, for a mine, like a glacier, seems ever to be working. This is all below ground. Above the surface is a world of machinery, always to be kept in order—steam engines, air engines, cables, cages, air pipes, pumps and, all the multiplied devices intended to expedite the work and lessen the dangers of mining. Five hundred men have to be lowered into and hoisted from the depths daily. Three hundred cords of wood have to be provided daily for fuel. And there must be no delays, no serious accidents. The needed repairs must be anticipated and provided for; the accidents must be anticipated and guarded against; the explorations must be carried on months in advance; the supplies must never fail. A vast space of forest land, 30 miles away, has to be denuded of its timber yearly to fill the insatiate maw of this one mine. It requires 15,000,000 feet of timber and 100,000 cords of wood annually to supply the mine and to furnish fuel to hoist and reduce the ores. How many can appreciate the ability necessary to carry on this work without any mistakes? Many a man of mind sufficient to accomplish the feat would fail through sheer lack of physical strength. The work means being up at five o'clock in the morning; means two or three daily journeys into the depths, and when anything unusual happens, it means standing guard day and night, like a ship's captain in a storm, until the trouble is over. It means a mind large enough to take in the immense work going on at a glance, yet careful enough to include its smallest details, and exact enough to anticipate the wants of the enterprise months in advance. For ten months the California mine has monthly given up this tremendous yield.

THE amount of phosphorus yearly manufactured in Germany is 250 tons, which is about one-half the entire production of the world.

THE total amount of tea grown last year in India was 28,000,000 pounds.

VENTILATION OF ROOMS.

AT a recent meeting of the Society of Arts, London, Dr. W. B. Richardson presiding, when a paper was read by Mr. Frank E. Thicke on "Ventilation of Rooms generally, and the way to make Workmen's Cottages Comfortable, Warm, and Healthy." In the course of his paper, Mr. Thicke remarked that the only thing to be done in reference to the admission of the outer air into an apartment was to regulate it in such a manner that, when it reached the sensitive part of the face or neck, no disagreeable current or draught should be experienced, and this was easily accomplished by passing a current of cold air (no matter how powerful) through finely perforated zinc wire, gauze, muslin, or cotton wool, which would divide the cold air into such fine streams that they would all become warmed by the air in the room before reaching the sensitive face or neck. Having decided upon the admission of this air, let them inquire the proper places for such influx. Some recommended the upper, some the lower, part of a room. He himself preferred both, through holes obliquely bored upwards—1st, beneath the floor to inside of fender; 2d, through lower part of door, and covered with perforated zinc, fixed in a sliding frame; 3d, through upper part of door and ditto; 4th, through a window guarded with perforated zinc and working on a pivot, so that the lower one might be used at one time and the upper one at another, in this our English climate, because it would be grateful in the summer months through the lower openings, and not disagreeable through the upper openings in the winter ones. Now that after the late conflagration at the Brooklyn Theatre, with its 300 deaths, we had been promised a more ready escape from fires in such unhealthy places of amusement, he ventured to express the hope that at the same time the Lord Chamberlain would insist upon as ready an escape for vitiated air in theatres, not omitting the regulated and agreeable admission of an ample supply of the outer air. The whole of the trees (he afterwards remarked) on the Albert Embankment, from Lambeth Bridge westwards, had been removed, the reason being, as we were informed, that the exhalations from the adjacent potteries had destroyed their vitality. The subject was serious from a sanitary point of view, and no less so in its æsthetical aspect, as fumes which proved so deadly to vegetation could not fail to have fatal effects, not only on human beings but possibly on the architecture of the buildings around. The combustion, also, of five or six millions of fires in London largely diminished the sustaining properties of the atmosphere, by robbing it of the very oxygen we required, and the Government spent about £200 in cotton wool alone yearly for the purpose of filtering the London air before the members of the House of Commons, etc., breathed it. Yet the noxious gases which crossed the Thames to kill the above trees would also enter the Houses of Parliament, and they defied the cotton wool to arrest them, just as the polluted water of the Thames defied the water companies' filters, through which impurities passed. Mr. Thicke proceeded to direct attention to a ventilator invented by Dr. Ancell Ball, which, he said, might be regarded as a tube, about 25 in. to 27 in. long, bent upon itself in a somewhat syphonoid form. It was more than a syphon, being composed of an ascending, descending, then ascending channel, amounting, as it were, to a syphon and a half, or what he might term a sesqui-syphon, the object in view being partly to reduce the length of the tube to its present height, as well as to increase the strength of the current through it. Having described the *modus operandi* of this ventilator, Mr. Thicke went on to speak of the mode of carrying off the impure and vitiated air in a room as fast as it was generated there—either night or day—by placing this efflux ventilator in the breastwork of the chimney, just beneath the ceiling, with one opening communicating with the room and the other within the smoke flue, when of the two currents, viz., the syphonic and smoke flue, one would be brought into play, and draw the impure air out of the room, through the ventilator into the chimney, where it would blend with the smoke and be carried off, and in summer without the smoke. The size of this syphon ventilator was such that it would convey away the impure air of half a dozen persons as fast as it was expired or breathed into an ordinary sized apartment, so that what was now considered by a sanitary inspector as overcrowding would not be deemed so by adopting this plan, which agreeably admitted, all night long, and ample supply of pure air, at the same time carrying off the vitiated air as fast as it ascended from the mouths of the inmates to the ventilator. Mr. Thicke proceeded to suggest for consideration the propriety of erecting in different localities blocks of buildings, with one room only in each tenement, having a slight recess to hold a couple of shut-up iron beds, concealed in the daytime by a curtain. He also suggested a cooking grate in one corner, so that four fires might be worked by one chimney. This single room, if properly ventilated, would sleep a man and his wife in one bed, and three children in the other. A superintendent should reside in each block, and a licence granted to it, that the police might inspect it under the Lodging-house Act. There should also be a small mortuary connected with every block, so that any fatal case from an infectious disease might be deposited there at once, and if a small well-ventilated nursery or hospital could be spared at the top of the building for the early isolation of cases of small-pox, scarlet fever, or measles, etc., and their disinfection, he was sure many epidemics might in this way be arrested, nay, often altogether prevented. The speaker went on to show how the cost of plastering the walls of cottages, etc., could be saved by abolishing paper-hanging and substituting silicate wash or petrifying liquid, and to direct attention to Dr. Ball's patent Janus—a double-faced grate, economical (he said) in the consumption of coal and excellent for heating rooms. In conclusion, he remarked that he thought there might, in connection with this subject, be some advantage in Government interference by sanitary inspectors, based on experiment, which should be more searching than was at present the case. We wanted a minister of public health as well as of public works—in fact, the former was the more necessary of the two—Mr Thicke having concluded his paper, the Chairman made some observations, in the course of which he pointed out the necessity which existed for a great national movement for improving the homes of the people. It was (he said) one of the most important points in the advancement of sanitary reform that no sooner did we begin to work for the present generation than we began at that moment to work for future generations, and it was impossible to contemplate what, in the matter of some 60 years, would be the difference in health, compared with the state of health at present, if our sanitary measures continued to proceed as they were doing now, and if we got into the way of making one generation healthier than another. He approved of Dr. Ball's Janus grate, and of Captain Dalton's stove, and said he regarded the use of silicate wash as an advance in sanitary science.

UNCONSCIOUS EDUCATION.

A FEW evenings ago, a little party of children were gathered in a pleasant parlor to look at some "views" exhibited with the use of a fine magic lantern. Among the pictures thrown upon the canvas were some very ordinary ones, entirely devoid of artistic beauty. All the children but one were, in spite of their quality, delighted with all the pictures, and applauded all with remarkable impartiality. There was one, a little girl of but four years, who, after a few of the poorer pictures had been shown, cried out, "I don't want to see any more of those horrid things." Curious to know why she was more discriminating than her fellows, we found, upon inquiry, that she had been trained in a home where an abundance of the best pictures adorned the walls, her own playroom having a profusion of them. Insensibly her eye had been trained to fine perceptions of artistic beauty, and the pictures which pleased other children offended her good taste.

It is almost impossible to estimate the importance of this unconscious training of the eye, even among the youngest. The incident we have related shows how much is possible from the art education which has been introduced into our common schools. There has been much opposition on the ground of the uselessness of this among the younger scholars. But it is far from useless. Right impressions can be made far earlier than we imagine, and with this training, begun very early, we shall find the development of a generation out of which better mechanics and artists will come than can possibly be obtained without it.—*Commercial Bulletin.*

RECENT TRIALS OF THE 80-TON GUN.

February 1, 1876, the 80-ton gun was fired, for the first time, against armor. The construction of the target is shown by the cuts. It may be observed that the 8 in. plates are coupled together in pairs by bolts—that is to say, that the front plate is bolted to the second one, the second to the third, the third to the fourth, and the fourth to the horizontal beams in rear. The bolts employed are 3 in. in diameter, they are those known as the Palliser English bolt—that is, the shank of the bolt has the Palliser projecting screw thread on it, while the head is made on Captain English's ball and socket principle, with the hole in the plate allowing play round the neck of the shank, so that one plate may move slightly on the next without shearing the bolt. The front view of the target, Fig. 1, also shows the target supported by strutted piles at the ends and weighted with an old armor plate on the top to keep the teak filling from escaping under the force of the blow of impact. The target is designated No. 41, in succession to the one—No. 40—constructed of three $6\frac{1}{4}$ in. plates with 5 in. layers of teak between, which is now strengthened by the addition of another $6\frac{1}{4}$ in. plate and 5 in. of teak to make it a match for the 38 ton gun which has recently been chambered.

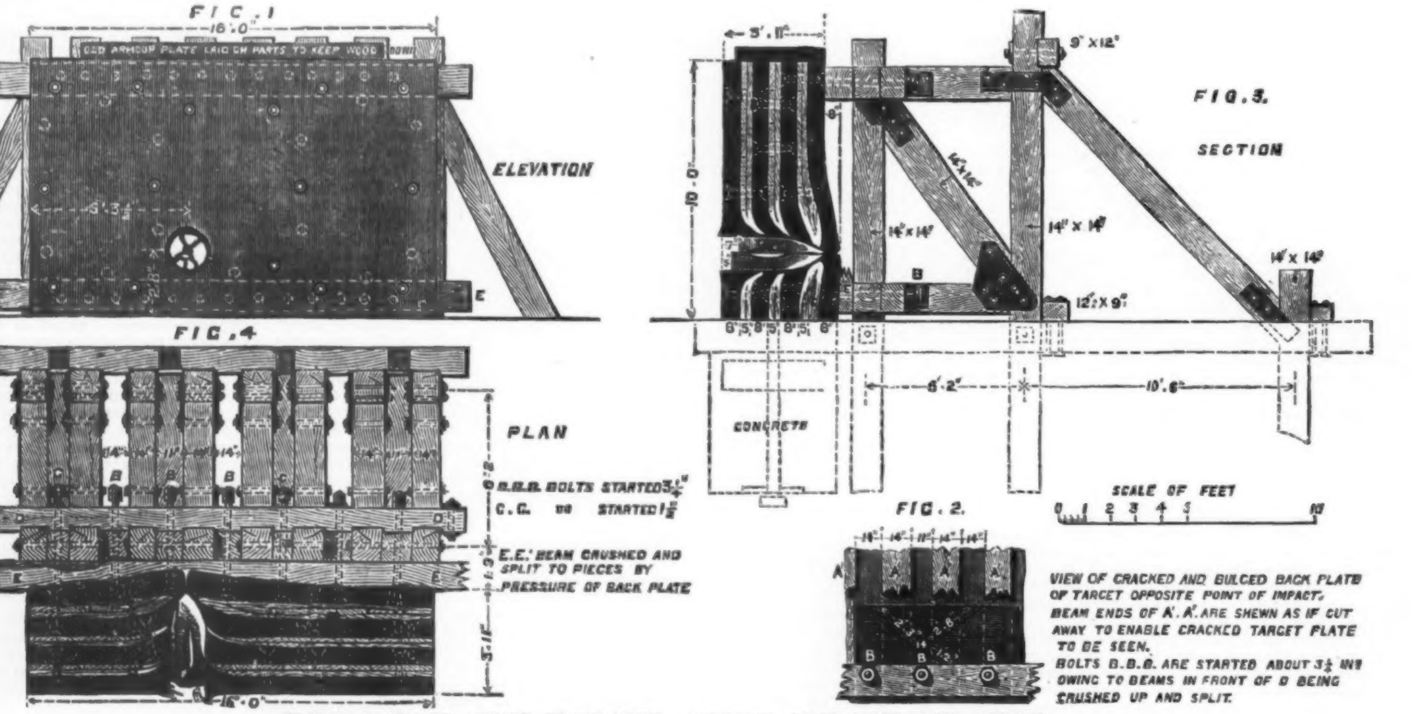
The gun was charged with 370 lbs. of powder—cube 1·5 in.—and a Palliser projectile filled with sand to 1,700 lbs. weight—including gas check—and plugged. This projectile was of the service form, having an ogival head of $1\frac{1}{2}$ calibres radius.

The initial velocity at the muzzle was 1,510 ft. per second, the work stored up being 27,000 foot-tons, or 537 foot-tons per inch circumference. The target was at a range of 120 yards, at which point the velocity was found to be 1,496 ft., and the stored-up work 26,400 foot-tons, or 525 foot-tons per inch circumference. We may note in comparison with this that the 100-ton Elswick gun at Spezia, when fired against armor, had a charge of 341·6 lbs., giving a velocity of about 1,500 ft. a second, and stored-up work in one case of 31,200 foot-tons, or 584 per inch circumference—that is to say, the Spezia shot had not only more stored-up work in it, but also more power per inch circumference, and therefore more punching power. The shot referred to completely penetrated Marrel's target, consisting of 22 in. of iron, 29 in. of wood, and $1\frac{1}{2}$ in. of iron skin strongly supported by iron girders. It was not to be expected that the 80-ton shot could equal it in penetration, while the target it was to fire at was considerably stronger than the Spezia targets, though it is difficult to say how much. The estimate in our last article of 6 in. of iron might be perhaps applicable to the sandwich Spezia targets, but certainly not to those covered with solid 22 in. plates. Any comparison between plates on such different systems of arrangement is based a good deal on conjecture, but it may be said safely that the Shoeburyness target was decidedly stronger than any of the Spezia targets. The structural weakness we pointed out that appeared to us to exist—namely, the want of support at the back—would cause the entire shield to bend back more easily, as the event proved; but this would render it more difficult to penetrate.

The shot struck a spot 6 ft. $8\frac{1}{4}$ in. from the proper right edge of target—that is, the left looking at it—and 9 ft. 8 in. from the ground line, measuring to the center of the hole, which is the spot where the point of the shot struck. The projectile buried itself in the target, the base being at a distance in from the target face of several inches. The base, and probably the entire projectile, was split longitudinally, as shown in Figs. 1, 3, and 4. The segment on the left side of a person facing the target, and also the proper left of the shot, had gone in to a depth of 7 in., the remaining portions of the shot being only 5 in. deep, measuring from the rear face of the base proper, the gas check having been detached and left behind as the shot entered. The back of the target was starred in a crack shown in Fig. 2, and bulged back 7 in. It is impossible to speak positively of the condition of the body of the projectile. It is probable, however, that if broken transversely the base is not left far behind the rest of the shot, because the length of the shot is such that its point must in that case have been so close to the back face of the target that it would have been seen or felt through the cracks. On the other hand, when it is remembered that ogival projectiles in penetration crush and sweep the metal back round the hole, it is scarcely likely that, with so little wood and so much iron round it, the fragments of shot can be sensibly displaced laterally. The star crack at the back also is very nearly opposite the shot base, and there is every appearance in the character of the bulge of the shot's point being directly below the star, although the crack was not such as admitted of its being felt by a probe, being choked up with wood and langridge. Altogether it appears probable that the shot, whether broken transversely or not, occupies about the position it would occupy if unbroken beyond what is seen at the base. We have therefore shown it so in Figs. 3 and 4. In this case the point of the shot is near about the line occupied by the back face of the target before it was fired at, for the length of the shot is 42 in., which, added to the 5 in. penetration behind the base, makes up the exact thickness of the entire target. Supposing the point happens to be on the segment, which is 7 in. deep, it would imply rather deeper penetration. It may be surmised, then, as the rear plate has bent back 7 in., that the point of the shot is about an inch into the iron of this plate, and still has about 7 in. of iron in front of it, which iron, being cracked and bent, would offer a greatly diminished resistance to further penetration.

The horizontal beam at the base of the back of the target—E in Figs. 3 and 4—is crushed and split into ribands—and as a natural consequence the bolts holding the rear plate to the next horizontal beam behind, having gone back with the plate, project in the rear—as shown in Figs. 2, 3, and 4—to an extent of about $3\frac{1}{4}$ in. in the three bolts opposite to the blow, and $1\frac{1}{2}$ in. in the two right and left of these three. The whole target structure is a little sprung and shaken. The effect must be considered very good. The gun has done perhaps rather more than would be estimated, though sufficiently near it to show how good an idea may now be formed by calculation. Royal Laboratory projectile, which had been made without studs and with an ogival head of $1\frac{1}{2}$ diameters radius, was not fired. The committee, basing their opinion on experiments conducted many years since, when heads of 1 diameter and $1\frac{1}{2}$ diameters radius were tried, either did not expect much advantage to be possessed by the sharper point, or they did not consider that a spot on this target could be profitably devoted to the object of comparing different forms of heads, which, if desired, might be done on a smaller scale. The value of such an experiment, however, would in our opinion be that it would furnish a more complete relationship between all the experiments carried out in this country and those at Spezia and elsewhere abroad, and we could have wished that it had been done. Knowing that the opinion is held strongly in the Royal Laboratory that their shot would penetrate better with the sharper point, and that this point is, we believe, universally adopted abroad, we cannot be sure that we are not placing ourselves at a disadvantage by not using it, and the experiments on the points of 1 diameter and $1\frac{1}{2}$ diameters do not necessarily apply to the question between $1\frac{1}{2}$ and $1\frac{3}{4}$ diameters. The tangents to the points of these shot make angles of 120 deg., 96 deg. 24 min., and 83 deg. 50 min. respectively, which show, no doubt, a more apparent difference between the 1 and $1\frac{1}{2}$ than between the $1\frac{1}{2}$ and $1\frac{3}{4}$ diameters ogival head.

Later in the day a blind common shell was fired from the 80-ton gun at an old 8in. unbacked plate, which was completely demolished, being split and broken across, and thrown round out of its position. The shell broke up, the greater portion going on into the sea. What is the precise value of this experiment it is difficult to say. Looked at from the ship's point of view, there appears little to be learned. From the artilleryman's point of view, it may be gathered that the 80-ton gun might fire common shell in preference to Palliser projectiles with advantage at any lightly armored ship though it is difficult to say what class of armor is equivalent to the perforated and damaged 8 in. plate that was fired at on Feb. 1.—*Engineer.*



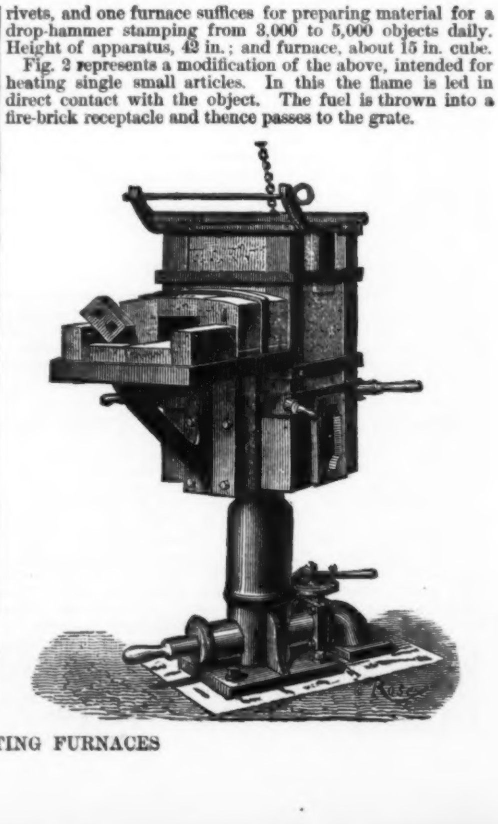
THE 80-TON GUN TARGET AFTER IMPACT OF SHOT.

NEW RIVET-HEATING FURNACES.

We illustrate, in the annexed engravings, a new and quite hardy furnace for heating rivets and other small objects. It is the invention of MM. Bonchacourt & Delille, of Fourchambault, France. In the apparatus represented in Fig. 1, wrought iron cage is lined with fire-brick, and in openings in the latter the objects to be heated are deposited. These are inserted from above by simply lifting the cover. Below the cage is an ash-pit, into which opens the blast-pipe. The grate is arranged on a drawer, so that it can be moved bodily outward when the fuel needs replenishing.

The furnace is supported on a hollow standard, which also serves as a pivot and as a conduit for the blast. The latter enters on one side of the base, where a regulating valve is placed. On the opposite side, entrance may be had to the interior of the standard for cleansing it. The daily consumption of fuel, says the *Moniteur Industriel Belge* (whence we extract our engravings), varies from 110 to 330 lbs. of coke, according to the force of the blast. On an average, 33 lbs. of coke serves to heat 220 lbs. of $\frac{1}{2}$ inch rivets, and one furnace suffices for preparing material for a drop-hammer stamping from 3,000 to 5,000 objects daily. Height of apparatus, 42 in.; and furnace, about 15 in. cube.

Fig. 2 represents a modification of the above, intended for heating single small articles. In this the flame is led in direct contact with the object. The fuel is thrown into a fire-brick receptacle and thence passes to the grate.

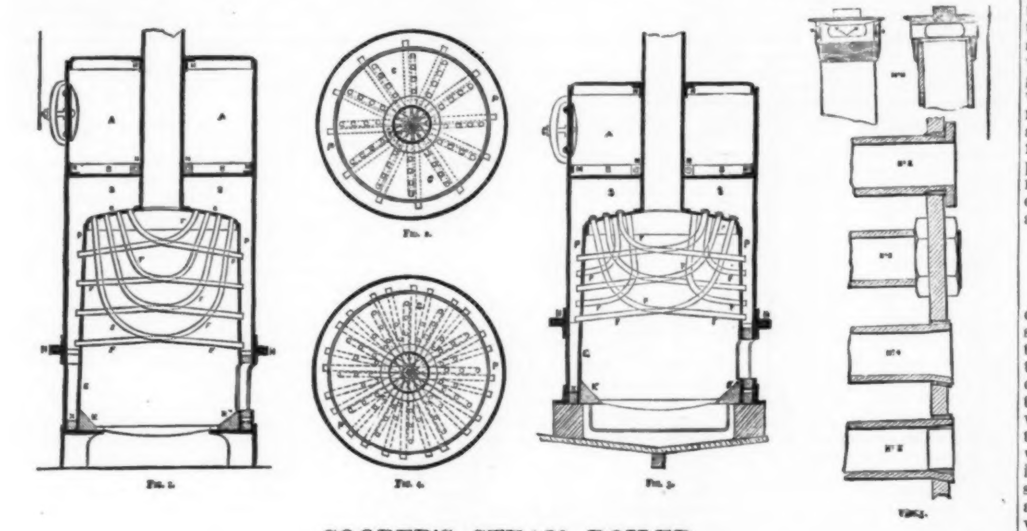


NEW RIVET-HEATING FURNACES

COOPER'S STEAM BOILER.

FIGS. 1 and 2 show, in plan and elevation, a comparatively simple form of the water-tube arrangement. They are arranged in four rows spirally ascending above one another. The tubes, F, start from the water-space around the fire-box, and first run horizontally until they have passed the center of the boiler, when they ascend with an easy bend and issue vertically from the crown of the fire-box. This arrangement gives a tube cutting transversely across the current of hot gases for a considerable distance of its length, checking most perfectly, as seen in the plan, the too ready exit of the hot gases up the chimney; and then, by the easy upward bend, giving the very best incentive to free and rapid circulation. It is to be noticed that the lower ends of the tubes are not flush with the fire box, but project some distance through, viz., about halfway to the outside shell. By this means the coldest water is drawn into the tubes for circulation. This little point is as valuable as any in the boiler. The concentration or maximum intersection of the tubes at the center of the fire-box is also a valuable feature, leaving the fire-box walls comparatively free.

This is a point much missed in nearly all the present multitubular boilers extant. The exit to the chimney direct from the fire is usually too free and open, inducing a current outwards in that direction rather than amongst the tubes, whilst at the same time the tubes are thickly congregated inside the walls of the fire box, keeping from them a very large proportion of the heat which they would otherwise absorb. In Cooper's boiler all the usual efficiency of a plain fire-box, together with the additional heating surface of the tubes, is obtained; and still further, the direct exit of the heat is most effectually diverted on the walls of the fire-box and tubes. Figs. 3 and 4 show, in elevation and plan, a lower arrangement of boiler, specially suited to steam launches. In this case, to allow for reduced height, additional bent tubes are inserted into the fire-box, between the more open ends of the horizontal crossing tubes. These additional tubes are very similar in application to the Davey-Paxman tubes, taking water from the water space, around the fire-box, and delivering through the crown plate, by an easy bend. The exceptionally small diameter of these tubes is a feature about them which distinguishes them from most of the others in use. The proportion recommended by the inventor is a quarter of an inch diameter of tube to every foot diameter of boiler. The arrangement of a dash-plate, B, or anti-primer, is rather a novel feature, and ought to prove tolerably successful, especially in cross sea ways.



COOPER'S STEAM BOILER.

The question of the method of securing the tube ends in a boiler shell is a most important one as regards tightness and efficiency. A boiler tube fastening should be both exceptionally easily put in and easily removed; and when removed should allow the tube to be withdrawn with perfect facility. These objects are very well attained by a peculiar jam taper ferrule, which is screened both sides, so as to wedge itself home between the plate and the tube. The plate is, of course, tapped with a taper tap, and the tube end is screwed down taper. This locking ferrule is shown in No. 2, Fig. 5.

A further useful adaptation of this double-screw ferrule is to use it as a water and steam deflector at the upper or exit ends of the steam-tubes. By casting this ferrule with a solid cap, but with horizontal orifices, the issuing stream of steam and water is broken, so as to prevent priming, whilst at the same time the water is distributed over the crown of the fire-box. This appears a most effective deflector, and is one of the simplest we have seen.

The practical arrangements for repair and cleaning are good. The boiler may be separated by breaking the turned angle-iron joints, at H and K, which are made with bolts, to allow of this. The upper shell may then be completely lifted off, leaving all the fire-box and tube ends bare and open to inspection and repair. The pockets, X, in which most of the deposit and silt will collect, may then be easily cleaned out. This double-joint is, however, always rather difficult to make tight simultaneously, and the lower angle-joint, at H, can never be kept tight for long, unless the angle-irons are supplied very stiff.

We understand that a trial boiler, in the hands of the makers, William Wilson & Co., of Glasgow, Scotland, has given very satisfactory results.—*Iron.*

BOILER-SHELL DRILLING MACHINE.

ONE of the most laborious portions of the work done upon a boiler is the punching of the rivet holes and the after riveting-up. It is principally upon these two items of workmanship that the soundness of the boiler depends. There is much that may be said against the practice of punching boiler-plates, and the subject has been often ventilated in detail and much discussed. The punching is rarely done with anything like accuracy, and any undue haste in the production of the boiler would materially tell against the correctness of this portion of the work. When, then, the plates are brought together for riveting, the holes are so far out, that the injurious practice of "drifting" has frequently to be resorted to, in excess of what the plate can bear. The holes become distorted, so that the rivets will no longer properly fill them up, and it is a common thing to see even the edges of the plates split by the excessive strain.

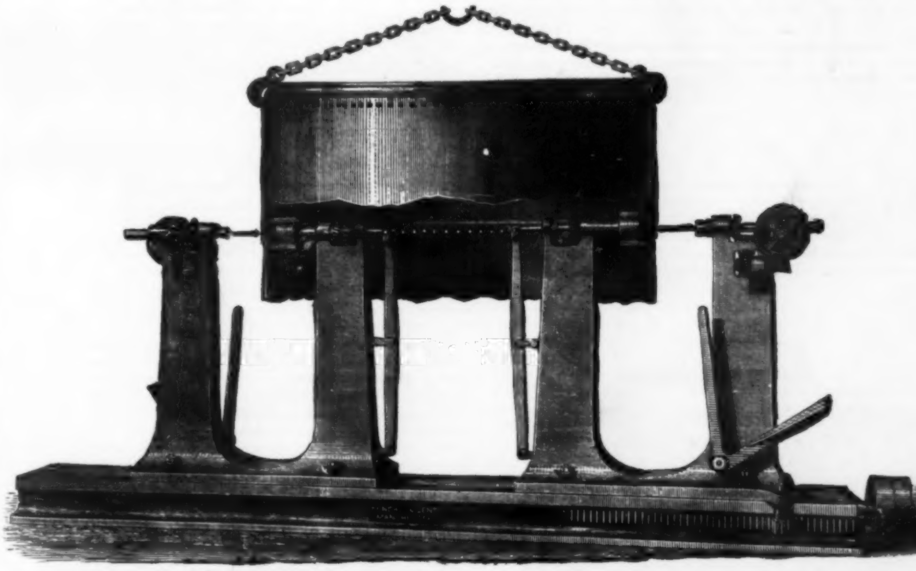
To remedy these obvious evils, drilling has long been advocated as the best way in which to pierce the boiler-shell. But this system is only of the best efficiency when the two plates to be riveted together are drilled simultaneously when placed in suitable juxtaposition. This means that they must be first bent, or formed in shell, and this will necessitate the use of a special tool to effect the drilling with promptitude and ease.

The tool we illustrate is made by Kendall & Gent, of the Victoria Works, Manchester, England. The boiler-shell may be conveniently slung by chains in a vertical position between two pairs of headstocks carrying horizontal drills, so that the transverse joints may be all drilled by rotating the shell as each hole comes in succession between the headstock drills. The machine in question is designed to take a boiler-shell of from 4 feet 6 inches and upwards in diameter.

The two double headstocks are carried on a traversing horizontal bed to enable them to slide closer or apart, as required, to suit the varying diameters of boiler-shells, by means of independent rack and pinion gear. Each headstock is supplied with two drills, one of which is for drilling the holes, viz., from the outside of the shell, and the other, from the inside, is for counter-sinking. The inner headstock also carries two crutches or prongs, against which the boiler-shell presses when the outside drill is brought home to its work.

The drills are driven by bevel gearing from upright spindles in the hollow headstocks, which again are driven by the horizontal shaft running along the bed-plate and the two pulleys seen at the end of the bed-plate. The piercing drill has a self-acting feed, but has also a hand-wheel by which it may be quickly withdrawn as soon as the plates are pierced.

After the piercing drills have completed their part of the work, and are withdrawn, the counter-sinking drill is brought up to its work before the position of the shell is moved. The counter-sinking drill is kept there by the action of a hand-treadle lever, carried to the side of the machine and outside the boiler-shell. This places them handily for the operation of the machine hand.



MACHINE FOR DRILLING BOILER SHELLS.

When the boiler has been duly slung and set for a ring of holes, which may be easily set out by template, the drills may be attended to by two laborers, and the holes rapidly drilled and counter-sunk ready for riveting up. There is thus no drifting of the holes required. The work turned out by these machines, though cheaply done, should thus be of the very highest character for accuracy and strength. At the same time the simplicity and easy working of the tool will make it a favorite in the workshops, being within the skill of any laborer. This machine has already been tested and approved in one of the principal boiler-maker's shops in Lancashire.—*Iron.*

NEW DEVICE FOR RAISING WATER.

M. TH. FOUCAULT has recently produced a new apparatus for raising water by means of ammoniacal gas. The machine depends for its operation on the facts that water at 15° C. absorbs 743 times its volume of ammoniacal gas, and gives it off again at 60° C.; that at 100° C., the tension of the vapor is seven and a half atmospheres; that petroleum and ammoniacal gas are without action upon each other; and that the same is true of petroleum and water. The apparatus consists substantially of a heater, which is partially filled with a strong aqueous solution of ammoniacal gas. This heater is connected by pipe with the upper part of a closed reservoir, the lower part of the reservoir being connected by means of pipe and suitable valves with the stream or well from which, and the tank to which, water is to be raised. The reservoir contains a small quantity of petroleum, which forms a thin stratum on the surface of the water, and serves to keep the ammoniacal gas from contact with it, and, as the inventor expresses it, forms a fluid piston. The operation is as follows: Supposing the reservoir full of water, the temperature of the heater is raised by suitable means, ammoniacal gas is given off, and passes over into the upper part of the reservoir, the stratum of petroleum preventing its being absorbed by the water there. A pressure is thus created in the reservoir, which forces the water there out and up to the tank to be filled. When all the water has been forced out of the reservoir, the heater is cooled by removing the fire and allowing a jet of water from the tank to play on it. The water in the heater, as it cools, re-absorbs the ammoniacal gas from the reservoir and thus creates a vacuum, which the water from the stream or well rushes up to fill, and thus refills the reservoir. The heater is then heated, and so on, as before. The inventor claims that the consumption of fuel is almost insignificant as compared to that of a steam pump of the same capacity. The author also describes a modification of his apparatus adapted to be run by the heat of the sun, in which case the only expense is that of wear and tear, which is small, there being no moving parts.

RACING AT SEA.

THE term "racing," as known to marine engineers, is very different in its meaning to the same term as applied to equine sports on shore. It is not necessary to describe the meaning of the latter, but the former may be briefly explained. It relates to the habit which engines have under certain circumstances of running on at a very rapid speed, and knocking themselves to pieces by the process. Racing is most common on board vessels fitted with screw propellers. The reason for that is this—the screw in stormy weather sometimes revolves in water, and at other times its blades simply beat the air. This is, of course, owing to the pitching of the ship. When the screw is wholly submerged the sea forms a fulcrum for it, and the engines find that substantial resistance to the power which is necessary to keep them steady. When, on the other hand, the screw is bodily out of water, and in its revolutions meets with no fulcrum, the engines are simultaneously released from their heavy duty, and they fly off or "race" at a fearful speed. The inconvenience and danger of these alternations are obvious, and in heavy weather it has been usual to station a hand to watch them, and to turn on, or cut off, steam from the boilers as occasion required. Many attempts have been made to cause the engines to thus feed or throttle themselves automatically. Until lately this desideratum seemed unattainable, but now a Mr. Hill seems to have accomplished as great a feat, and electricity is the agent he employs. The contact-making parts of his newly devised apparatus is fixed to the outside plating or planking of the vessel, and a small "button" rests there on a diaphragm upon which the sea water impinges freely. A three-quarter inch hole is bored at the stern near the screw, and over this hole the button and diaphragm are placed. As the water either covers or leaves the surface of the button (or small plate of metal, as it really is), and which is governed by the pitching motion of the ship, the button is depressed, or else compelled by the elastic action of the diaphragm to expand. In the one case it cuts off, and in the other it sets on, the electric current. This current magnetizes a magnet which is carried on the crank shaft of the engine, and one arm of which is connected with the throttle valve. So long as there is no current passing, and this is while the outer button is under water, the magnet is kept back, and the throttle valve is kept open by means of a weight. When however, electricity begins to pass, which is when both the screw propeller and the button are out of water, the poles of the magnet instantly adhere to the revolving shaft, and the magnet, acting through the arm just named, shuts the throttle valve at once. This prevents the admission of steam to the cylinders, keeps down the speed of the engines, and thus

destroys all their racing propensities. When the contact is broken by the submergence of the screw, the magnet falls back, the throttle valve opens, and the engines go on as usual. Perhaps the extreme simplicity of this anti-racing appliance of Mr. Hill, together with its manifest efficiency and non-liability to derangement, constitute its principal ad vantages. The inventor may, therefore, be justly congratulated on his success, and there is little doubt that his plans will find favor at the hands of steamship owners at home and abroad—at least they deserve to do so.—*London Echo.*

[Journal of Gas Lighting.]

PIPES FOR GAS AND OTHER PURPOSES.

(Continued from Supplement, No. 64).

We come now to treat of spigot and socket, or, as some prefer to style them, spigot and faucet joints. This is the class of joint, in one form or another, most commonly in use for gas-mains; and, taking into account the various advantages it offers over others in point of cheapness, facility in connecting, and permanent durability when well made, it may with confidence be pronounced the most suitable for adoption.

There are two distinctive kinds of this description of joint, viz., the open, and the bored and turned. It is of the former that we shall first speak. Pipes so manufactured have the inner diameter of the socket larger than the outer diameter of the spigot; the latter, consequently, fits loosely into the former. For cast-iron mains of the smallest size up to eight inches in diameter, this open jointing space is three eighths of an inch, and for larger diameters half an inch wide all round. The following are the usual depths of the socket, inside measure, for the various sizes of open-jointed gas pipes, plugged with yarn and lead:

Diameter			Depth of Socket	
Up to 3 inches	....	=	3	inches.
4 to 8 "	....	=	4	"
9 to 20 "	....	=	4½	"
21 to 30 "	....	=	5	"
32 "	and upwards	=	6	"

For open-jointed pipes intended to be caulked with lead, the throat of the socket is cast with a slightly thicker body of metal than the tendency of splitting in the setting up of the joint.

The spigot end of the pipe may be either plain throughout its length, as in Fig. 16, or it may have a bead cast on, as in Fig. 17.

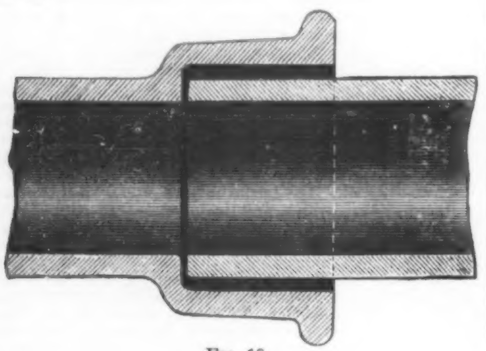


Fig. 16.

Some engineers prefer the former, stating, as their reason for the preference, that the end being plain admits of the full action of expansion and contraction without risk of the "drawing" of the lead, which they assert occurs with the beaded spigot. We do not share this view, as our experience justifies the assertion that whatever drawing of the lead may occur is due to quite another cause. In making this joint, the spigot having been inserted into the socket, a double fold of twined gasket is placed round the pipe, and, by means of a caulking iron, is driven within the open space; this is repeated three or four times, or oftener, according to the size of the mains being laid, the packing being well caulked all round, until, for a pipe, say of eight inches in diameter, the depth of the gasket is about two inches; the head on the spigot prevents the packing getting beyond the pipe end. Instead of dry hemp, a packing of tarred yarn is frequently employed. Our preference is for the former. The yarn of which it is made is usually of better quality than the other, and in absorbing the moisture, which is present in the mains, it is swollen to a degree of tightness not attained in the other case. The hemp plugging not only prevents

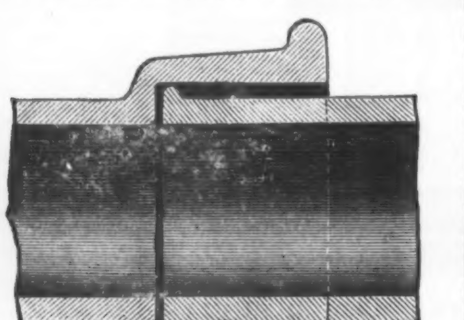


Fig. 17.

the molten lead from entering the pipe, but it allows a certain degree of play to the joint in the direction of its length, in becoming compressed by the contractile action of the metal of the pipe when submitted to a low temperature in the ground.

The packing of the gasket having been inserted and properly caulked, a piece of good tough clay, formed into a roll of the required length, is passed round the pipe, and pressed close up against the face of the socket, thus forming a fence to prevent the escape of the molten lead, which is now poured in through an opening or lip, formed on the upper side of the pipe, where the two ends of the clay meet. The socket being entirely filled, the clay is removed, and the operation repeated with the other joints. The lead, after being allowed to cool, is set up all round by means of a blunt caulking tool and hammer, the superfluous lead left in the lip of the clay being cut off with a cold chisel.

When the pipes that are being laid are of large diameter, a fence of iron, which is more convenient, may be substituted for the clay roll. This is made of flat iron 1¼ inches in width, by $\frac{3}{16}$ inch thick, bent to fit the outer diameter of the pipe in two half circles, like a pair of calipers, and hinged underneath, the ends meeting at the top being formed into a pouring gate for the lead. The instrument is clipped round the pipe against the face of the socket, and a thin luting of clay rubbed on the edges suffices to make it tight.

It is of importance, in making lead joints, that the ladle, out of which the molten metal is poured, should be of size sufficient to contain as much as will fill the socket at one continuous pouring. If this is not convenient, owing to the large size of the joint, then two men, each having a ladle, should pour the metal simultaneously, or other means should be employed to insure the same result. It is clear that if the lead, instead of being allowed to flow into the socket in an unbroken stream, is poured in a fragmentery way, the joint, when completed, will be less homeogenous and perfect.

Table giving the Weight of Lead in Pounds required for Jointing Cast-Iron Mains.

Diameter of Pipe in Inches.	Weight of Lead in Pounds.	Depth of Lead in Inches.	Diameter of Pipe in Inches.	Weight of Lead in Pounds.	Depth of Lead in Inches.
1½	1½	1⅜	11	16½	2¼
2	1¾	1¼	12	12½	2⅜
2½	2¼	1½	13	21	2⅜
3	2¾	1½	14	23½	2⅜
4	4	1¾	15	26	2½
5	5½	1⅞	16	28½	2½
6	7	2	17	31	2½
7	8¾	2	18	32½	2⅝
8	10½	2⅛	19	34	2⅝
9	12½	2⅛	20	35½	2⅝
10	14½	2¼	24	48	3

For pipes 1½ to 8 inches in diameter the lead is assumed to be about three-eighths of an inch thick; and in pipes 9 inches in diameter and upwards, half an inch thick.

The lead employed should be pure, without any admixture of tin, antimony, or zinc. We know that managers of gas works, in laying mains, are naturally disposed to utilize the scrap composition pipes of the store-room, and even old meter cylinders melted up together, for this purpose, with the laudable object of economizing the expenses. This is a mistake, as the more granular and brittle texture of the metals named militates against the soundness of the work.

The joint, to be as perfect as possible, should have an equal thickness of lead all round, and to insure this being so, the spigot should be concentric with the rim of the socket. The bead on the pipe end, if of the proper size, admits of this being accomplished without difficulty, and without the necessity of temporarily wedging the pipe, though the same end is attained with plain pipes, by having the throat of the socket cast in the form shown in Fig. 18.

In making a lead joint, there is more likely to be oversight and neglect than in any other. Careless workmen are apt to omit the proper caulking of the lead round the under side of the pipe, which is the most difficult of access, and where bad

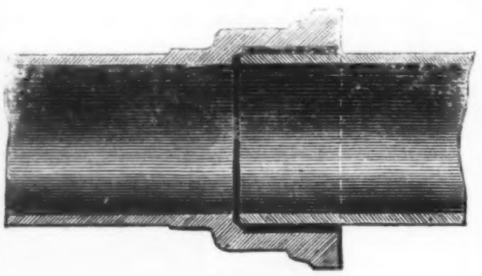


Fig. 18.

workmanship is not so readily observed by the manager or inspector; hence the reason of the frequent escapes of gas that are found to proceed from that part of the joint.

The work, also, is in danger of being slighted from other causes. In the streets of towns, through which heavy traffic has to pass, the opening of a trench is always a source of annoyance and obstruction; and, in the anxiety to complete the work, this is sometimes hurried to a degree which is incompatible with the making of good lead joints. In loose soils, also, the workmen are under the necessity, if the joint is to be well finished, of having to make a wide cutting in its vicinity, unless shoring is resorted to, to prevent the sides of the trench from slipping. These various causes operate to place the system of the ordinary jointing by means of lead at a disadvantage, and tend in the long run to augment the leakage account.

The principal advantage claimed by the advocates of the lead joint over the turned and bored, is the superior elasticity of the former, whereby it is enabled to adapt itself to the exigencies of settlement or subsidence in unstable ground, with less risk of leakage. Whilst admitting this to some small extent, we still believe that the alleged advantage is more fanciful than real. Wherever a depression of the ground takes place by which the pipes are carried down with the movement, a leakage or leakages inevitably occur. This is found to be the the case whether lead or turned and bored joints are employed; with this difference, however, that with the lead the gross leakage is distributed over a number of joints, and is less readily detected; whereas, with the turned and bored, it is generally either confined to one or two, or a fracture occurs at the weakest part in the line of mains, the concentrated nature of the escape (so to speak) insuring its speedy discovery and remedy.

For our own part, then, supposing there to be no alternative, we prefer the more rigid joint, even for treacherous ground, taking the precaution, however, to have the pipes made considerably stronger than under ordinary circumstances is necessary.

In a report to the New River Company, by Mr. Thomas Spencer, the principal objections to the lead joint when used for gas-mains are thus stated:

"Take the joint of gas-main that has been laid during warm weather, when its diameter and length are at their maximum. As soon as the coldest weather sets in, the size of this main, including its joint, will have reached its minimum. But in its progress from the one extreme to the other, it is evident that the joint must undergo disturbance, even though the lead and iron should expand and contract in an equal ratio. Unfortunately, this is far from being so, for the different rate of expansion between cast iron and lead is as 9 to 3½. In other words, the temperature necessary to increase a given length of cast iron 9 inches, will increase a similar length of lead only 3½ inches. It will now be obvious that a chief defect of the lead and iron joint for gas-mains arises from the important physical difference in the nature of the two metals. Notwithstanding the disturbance to which this joint is subjected by changes of temperature, it is clear that, if the metals composing it contracted and expanded in equal ratio, less injury would arise in practice. We see, however, that the lead and iron are each contracted to a minimum in winter; but as the contractile power of the lead is not equal to that of iron, it is obvious the latter, in contracting, will press the softer metal into a less diameter than it would have assumed naturally. On the return of warm weather, when the iron portion of the joint becomes expanded to its original diameter, *that originally belonging to the lead is never recovered.* Consequently space is left, between the iron and the lead, sufficiently large to allow of the constant escape of which we complain."

We entirely concur in these remarks, borne out as they are by everyday experience and observation.

Instead of lead, iron cement is frequently employed in plugging open-jointed mains. This is slightly more extensive than the lead, owing to its occupying more time in the manipulation; but in point of permanent efficiency it surpasses the other. The cement is prepared as follows:

98 parts fine cast iron borings.
1 part flowers of sulphur.
1 part sal ammoniac.

When required for use, mix with boiling water. This cement sets quickly. If required to set slowly, which makes the better joint, let the ingredients be in the following proportion:

197 parts fine cast-iron boring
1 part flowers of sulphur.
2 parts sal ammoniac.

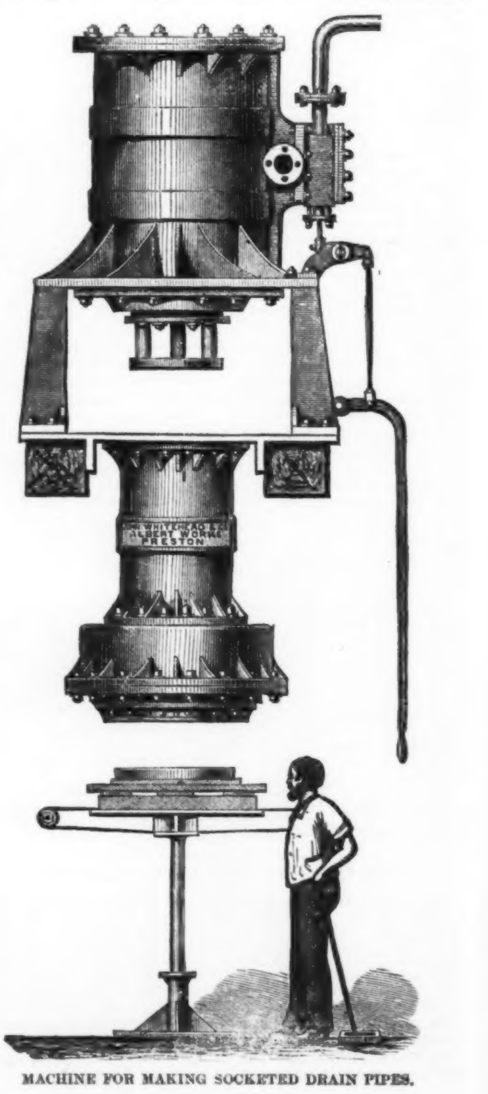
Mix the whole together thoroughly by pounding, and keep dry. When required for use, add hot water till the cement is of the consistency of mortar. The iron borings should be perfectly free from oil or grease.

Russian tallow and beeswax, melted and poured in between two gasket coils, have been tried as a substitute for lead, but with no very satisfactory result.

MACHINE FOR MAKING SOCKETED DRAIN PIPES.

The accompanying illustrations represent one of the direct-action steam machines constructed by John Whitehead & Co., of the Albert Works, Preston, Eng., fitted up with the patent metallic compressed air die for the manufacture of socketed sanitary or drain pipes.

Fig. 1 gives an elevation of the vertical-acting machine;



MACHINE FOR MAKING SOCKETED DRAIN PIPES.

Fig. 2 shows in plan the patented metallic die for making three 6-inch pipes simultaneously, similar in form to the sanitary pipe represented in Fig. 3. The upper cylinder of this machine is the steam cylinder, and is constructed in the same manner as those in ordinary use in steam engines. It is, of course, made of various dimensions in accordance with the size of the clay cylinder below it, and of the pipes intended to be made in these machines. The piston rods have a ram attached to them, which, upon steam being admitted to the cylinder, descends and forces the clay in the shape of pipes out of the clay cylinder, which is immediately below it. It will be seen from Fig. 1 that the admission of steam through the steam chest is under easy control of the attendant by means of a handle close to him. The clay cylinder is fitted with an expanding mouthpiece at the bottom, by means of which pipes of large diameters are obtained. The dies for both small and large pipes are attached to the before-mentioned mouthpiece, and on referring to our first wood-cut a balanced receiving table will be seen immediately under the die. As the pipe comes from the machine this table continues to fall, and as soon as the pipe is re-

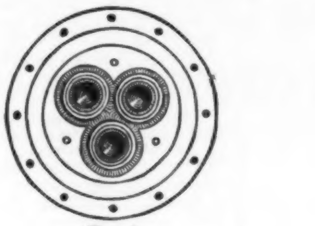


FIG. 2.

FIG. 3.

moved it rises with its face against the die in readiness for the ram to descend and push out another pipe. During the time the socket of the pipe is being formed, the table is held fast by a wedge actuated by a lever, the handle of which is shown in Fig. 1 in the hand of the man in charge.

On the attendant releasing the table, and on steam being admitted above the piston, the ram continues its down ward course, and the pipe or pipes, as the case may be, issues through the die. It is this die which is the chief peculiarity of the present machine, since it is entirely different from any other die both in principle and construction. It has no levers and flaps to be opened, closed, fastened and refastened, as in the machines hitherto used; on the contrary, it dispenses with these unhandy appliances altogether, thus saving much of the workman's time and labor. Another characteristic of this die—in fact, in this peculiarity the patent may be said to consist—is that the air is not allowed to escape from the die, but is held within it under pressure, so that as soon as the socket of the pipe is formed, and the table is released, the air immediately expands and very materially assists in propelling the newly formed socket from the mould or die.

Thus it will be seen that the action of the machine is simple and easy, and under perfect control of the workman. As has been already stated, three 6-inch pipes are made at once, and of 4-inch pipes four at one operation, and as these are made in less time than it has hitherto been possible to make one, the superiority of the machine as to increased production is obvious. Moreover, the quality of the pipes is much improved through the simple construction of the die; they are smoother both inside and out, and their socket much more evenly formed. The whole of the machine is constructed of the best materials and workmanship, being very powerful and efficient. The most usual machine is one for making pipes from 4 inches to 24 inches diameter, as well as all intermediate sizes.—*Iron.*

ON THE SOLUBILITY OF ETHER IN AQUEOUS HYDROCHLORIC ACID.*

By HARRY NAPIER DRAPER, F.C.S., M.R.I.A.

I AM unable to find that the fact of the considerable solubility of ether in aqueous hydrochloric acid is one generally known. It is not mentioned in any of the more modern works on chemistry, and the only reference to it is, as far as I know, made by Gmelin,† who says: "It "—ether—" likewise dissolves in aqueous hydrochloric acid without producing chloride of ether"—a statement which is referred to Boullay. The experiments which I have made in this direction will be better understood in the light of a preliminary note on the solubility of ether in other liquids. The following are the results of several independent observations: In saturated solution of calcium chloride ether is apparently quite insoluble. Distilled water at 12° C. dissolves, in 100 volumes, 10 volumes of ether. This solubility in water is quite in accordance with results hitherto obtained, but it is customary to state the converse case, *i.e.*, the solubility of water in ether, as 1 in 10, which is much greater than it really is. As the mean result of five experiments I have found that 100 volumes of ether at 12. C. dissolve 2 volumes of water. The error has obviously arisen in the use of ether not absolutely free from alcohol.

The ether employed in my experiments was found to have at 14° C the density of 0·725, but there is sufficient experimental difficulty in determining the weight of so volatile and expansible a fluid to prevent my attaching any considerable value to this figure. The ether was, however, shaken with finely divided acetate of rosaniline, and, as this did not communicate the least tint to it, it was concluded that it did not contain alcohol. For water it was tested by the immersion of bibulous paper saturated with alcoholic cobalt chloride and then dried. This remained blue after twenty-four hours, contact.‡

The aqueous hydrochloric acid was the strongest that I could conveniently work with. It had a specific gravity of 1·196 at 14°, and examined volumetrically was found to contain 38·52 per cent. by weight of real acid. Even at this strength it emits dense fumes when exposed to the air.

When equal volumes of the ether and hydrochloric acid just described are mixed together, immediate solution of the ether takes place, the temperature of the mixture at the same time rising considerably. There is also contraction of volume. When 50 volumes of ether and 50 volumes of acid are employed, the resulting solution, when cooled to the temperature which the liquids had before mixing, measures but 95 volumes, and at 14° C. has a specific gravity of 1·010. The solution flows like a thin oil, fumes in the air, is perfectly transparent, and remains so whether cooled to 0° or heated to 38°.

But hydrochloric acid of 38·52 per cent. will dissolve much more than its own volume of anhydrous ether. In a very early stage of my experiments it became evident that the quantity which it is capable of taking up bears an inverse ratio to the temperature, and that the volume of ether dissolved is at the ordinary atmospheric pressure constant for any given temperature. The experiments were made with a closely stoppered graduated tube, in which was added to a known volume of the acid a few volumes more ether than it was able to dissolve at the lowest temperature employed. The mixture was then cooled down to the required temperature and kept at this for an hour, during which time the tube was frequently briskly shaken and the volume of ether dissolved was then noted. In this way were obtained the results stated in the following table, in which the second and fourth columns give the number of volumes of ether dissolved by 100 volumes of hydrochloric acid, sp. gr. 1·196 at the corresponding temperature in the first and third columns:

Temperature Centigrade.	Vols. of Ether Dissolved.	Temperature Centigrade.	Vols. of Ether Dissolved.
— 16°	185·0	16°	162·5
0°	177·5	21°	157·5
+ 8°	172·5	27°	150·0
9°	170·0	32°	142·5
10°	167·0	38°	135·0

Thus, while at 0° C. 100 volumes of this acid dissolve 177·5 volumes ether; at 38° C. 135 voiumes only are dissolved. Or by weight, 100 parts hydrochloric acid dissolve at the lower temperature 107·5 parts ether, and at the higher but 81·8 parts. So that the capacity of hydrochloric acid of this strength for ether is nearly one third (31·4 per cent.) greater at the freezing point of water than at 38° C. (100° F.). I cannot recall an instance of so great a difference between the relation of solubility to temperature in the case of any two other fluids.

If the solution, saturated at any given temperature, be heated to a temperature higher than this, it at once becomes turbid from the separation of ether, and when the liquid is contained in a thin tube the contact of the warm hand is sufficient to produce in a few seconds complete opacity in a solution which, at the temperature of the laboratory, was quite transparent.

If a sealed tube containing the ether solution and excess of ether, first cooled (say in melting ice), then shaken, and the volume of unabsorbed ether noted, be suspended in a warm room, ether continues to separate in very minute bubbles until the liquid has attained the temperature of the surrounding air. When the tube is once more cooled to 0° without agitation, the liberated ether, being so much lighter than the solution, is not taken up again even after forty-eight hours, but on the tube being briskly shaken it is at once dissolved.

The increase of temperature at the moment of solution is considerable, being, with 10 c.c. of acid and 17 c.c. of ether, from 11° to 35° (*i.e.*, 22·50° C.).

No chemical combination takes place: the ether is simply dissolved by the acid, and can be separated by simple dilution with water. Thus 5 volumes of a solution (— 3 volumes ether) gave, on addition of 5 volumes of water, 2 volumes ether. By distillation nearly all the ether may be recovered. Two experiments were made in this direction, and in each case 17 c.c. were obtained from a solution which—calculating from the temperature at which it was separated—contained 19 c.c.

The solvent power of aqueous hydrochloric acid for ether is directly proportional to the strength of the acid. Thus the acid of 38·52 per cent., which I have used in my experiments, dissolves at 10° C., in 100 volumes, 167 volumes of ether, while the acid of the British Pharmacopœia, containing 31·8 per cent. HCl, dissolves at the same temperature but 125 volumes.

It should be noted that absolute ether dissolves hydrochloric acid from the aqueous acid. The acid of 38·52 per cent. was agitated for some time with excess of ether, the temperature being 12° C. The supernatant ether was then removed with a pipette, and its contained chlorine determined by an alcoholic solution of silver nitrate. It was found to contain chlorine equal to 2·409 per cent. of real hydrochloric acid.—*Chemical News.*

* Read at the Meeting of the Pharmaceutical Society of Ireland, February 8, 1877.

† "Handbook," vol. viii., p. 190.

‡ Much of the "anhydrous" ether of commerce reddens cobalt paper at once, and is itself very soon tinged by the rosaniline salt.

NEWCASTLE-UPON-TYNE CHEMICAL SOCIETY, JANUARY.

"On the Retardation of Chemical Reactions by Indifferent Matters, especially Glycerin," by Dr G. LUNGE.

The observations described below were occasioned by a number of experiments made on behalf of the Swiss Government, for the purpose of discovering a more reliable method of "obliterating" postage stamps than those hitherto in use. Among the stamping inks I prepared with that intention, there were several with a basis of glycerin, and I soon observed that if any acids were present in such mixtures, they comported themselves differently to coloring matters than if the same acids were merely used in dilution with water. This led me to make some experiments of a simpler nature:, and, although I have been prevented by want of time from following them up very far, and from extending them to that point which a true scientific treatment would require, I venture to lay them in that incomplete state before this Society, in the hope that they may not be found quite uninteresting; and that perhaps some one else will take the matter up with more leisure than I have had at my command.

My principal experiments were made upon the behavior of wrought iron (in the shape of wire nails) toward a mixture of glycerin and a hydrochloric acid. The hydrochloric acid contained 26·1 per cent. of real HCl, and was mixed with an equal volume of pure, syrupy glycerin. Check experiments were always made with the same hydrochloric acid, mixed with the same volume of water. Fuming hydrochloric acid can be mixed with glycerin equally in every proportion; nor does it act upon the latter chemically, at least not at the ordinary temperature, at which all my experiments were performed. Although the formation of monochlorhydrin would seem to be excluded by the very conditions of the experiment, I made sure of it by titrating the mixture before use; and, as may be imagined, I found its percentage of HCl exactly as calculated from the dilution, just as if the diluting fluid had been water instead of glycerin. The acid diluted with glycerin in many cases behaves precisely like that diluted with water; for instance, towards sodium carbonate, calcium carbonate, silver nitrate, sodium hyposulphite, solution of chloride of lime, litmus, etc.; at least, no difference could be noted in the preliminary tests, and it has seemed unnecessary to make quantitative trials. A difference, was, however noted in the case of paper stained blue by ultramarine. Whilst a strip of it in the acid diluted with water is beginning to be bleached ten seconds after immersion, and has become perfectly white in thirty seconds, another strip, dipped in the acid diluted with glycerin, only begins to be bleached after the lapse of forty-five seconds, and is only thoroughly whitened in four minutes.

The difference is, however, much more decisive in the action of the two acids upon iron or zinc. A bright wire nail (weighing 0·4927 grm.) completely dissolved in 6 c.c. of the acid diluted with water in ten hours' time, apart from a small carbonaceous residue. On the other hand, a nail (weighing 0·4875 grm.) immersed in 6 c.c. of the acid diluted with glycerin, weighed:

After 24 hours, 0·4200 = 86·2 p. c. of the original weight.
" 3 days, 0·2764 = 56·6 " " "
" 6 " 0·1405 = 28·8 " " "
" 14 " 0·0065 = 1·3 " " "

The solution still contained free acid, and behaved in every respect like an ordinary acid solution of ferrous chloride; for instance, towards precipitating reagents.

In another experiment, there were immersed:

(*a*). A nail weighing 0·385 grm. in 20 c.c. of acid diluted with water.

(*b*). A nail weighing 0·450 grm. in 20 c.c. of acid diluted with glycerin.

The evolution of gas (similarly to the previous cases) was much stronger in the case *a* than in the case *b*. After the lapse of three hours both test tubes containing the iron and acid mixtures were closed by gas delivery tubes, and connected with graduated cylinders inverted over a pneumatic trough. Eighteen hours later there had been collected from the tube *a* 74 c.c. of hydrogen gas, whilst the iron in it was completely dissolved. The experiment *b* was interrupted forty-four hours after the connection with the graduated cylinder, when only 52 c.c. of gas had been collected, and more than half of the nail was still left undissolved.

The action of the two acids on granulated zinc was much more rapid, but still showed a marked difference. 1 grm. of zinc, with 20 c.c. of acid and water, evolved 200 c.c. of gas in one and a half minutes; 1 grm. of zinc, with 20 c.c. of acid and glycerin took eight minutes to produce the same result. Other experiments, always with a similar result, were made with iron borings and hydrochloric acid; also with iron borings and sulphuric acid, diluted in one case with four volumes of water, in the other with four volumes of glycerin.

The cause of the retardation of the action upon metals in the case of acids diluted with glycerin can hardly be a purely chemical one, since, on the one hand, the glycerin is not acted upon, and since, on the other hand, it does not itself act either upon the reagents or upon the product of the reaction. The latter (ferrous chloride) is easily soluble in glycerin, as was proved by independent experiments, and it cannot, therefore, be presumed that the case is analogous to the insolubility of some metals in concentrated acids. Probably the real cause is—at least, partly—the viscosity of the glycerin, which is perfectly apparent even in the mixture with acids. The gas bubbles cannot liberate themselves very quickly from the iron, and thus prevent the contact between it and the acid. This assumption is supported by the fact, that the attack of acid upon iron is much more weakened by dilution with a solution of gum arabic than with pure water, as I found on trying it. But this explanation does not hold good for the retardation of the action of hydrochloric acid upon ultramarine, as well as in several other cases observed by me, and the following experiments do not in any way seem to be compatible with it. If fuming hydrochloric acid, diluted with the same bulk of water, be mixed with a little lamp-black (moistened with a drop of alcohol, to make the acid wet it), and if iron nails are immersed in the mixture, they are so little acted upon, that the evolution of gas is hardly perceptible at all; twenty-four hours after the nail looks exactly as it did at first. But if the mixture be now thrown upon a filter, and the same nail be placed in the acid running through the filtering paper, a strong evolution of gas commences immediately, and the nail is dissolved very soon.

The following quantitative experiments were made with a mixture of 50 parts of glycerin with 50 parts of fuming hydrochloric acid, and 3 parts of lamp-black. A nail weighing 0·536 grm. produced only after some hours a few minute bubbles of gas, and showed the following weights:

After 3 days, 0·4780 = 89·2 p. c. of the original weight.
" 6 " 0·4001 = 74·6 " " "
" 14 " 0·2575 = 49·0 " " "

In another experiment, a nail of 0·5766 grm. weighed:

After 3 days, 0·5124 = 88·8 p. c. of the original weight.
" 6 " 0·4440 = 77·0 " " "

The experiment was then interrupted by filtering the mixture. In the filtrate, 92 per cent. of the acid could be proved analytically; the remaining 8 per cent. might easily have been lost by incomplete washing of the slimy carbonaceous residue; but in any case there was far more acid in the filtrate than sufficient for dissolving the nail, and, in fact, the same placed in the filtrate at once caused an evolution of gas, certainly only at a moderate rate, as explicable by the presence of glycerin, and by the large dilution with the washing-water. Zinc behaves in exactly the same way towards the same mixture.

It does not seem impossible that this retarding action of indifferent substances may find a useful application, both for moderating chemical reactions in scientific operations and in technical operations on a large scale. It would give me great pleasure if this subject were pursued further by one interested in it, and if a satisfactory explanation of that phenomenon were suggested.

ANOTHER ANTISEPTIC.

DR. ZÖLLER, in a late number of the *Deutsche Industrie Zeitung*, states that carbon disulphide in a state of vapor is capable of acting as a powerful antiseptic. Two drops, allowed to evaporate spontaneously in a closed vessel of the ordinary temperature, were found to keep meat, fruit, vegetables, and bread in a perfectly fresh condition for several weeks. The articles submitted to the process acquire neither smell nor taste, the carbon disulphide evaporating entirely when they are exposed to the air at ordinary temperature. The vapor of carbon disulphide, being very inflammable, all experiments on its antiseptic properties should be performed during daylight.

MAGENTA IN THE BLOOD.—MM. V. Feltz and E. Ritter.—The authors find that the injection of pure magenta occasions paralysis, or convulsive agitation of the limbs.

THE ADULTERATION OF MILK.*

By Henry A. Mott, Jr., E.M., Ph.D., of New York.

This department of the subject of milk is, without doubt, the most important of all. Surely, every effort made to discover or point out the true method for detecting the adulteration of this most important fluid, which is so indispensable to the kitchen, the sick-room and the nursery, cannot help but be received with interest. For this reason I shall endeavor in this "paper" to consider in detail:

1st.—The Adulterants of Milk.
2d.—The Instruments and Methods for Detecting Adulteration.

Before proceeding with the discussion of the first division of the subject, it will probably be well to consider very briefly some of the peculiarities of milk, of which undue advantage are taken by milkmen.

Milk contains two elements, water and fat, both of which possesses a specific gravity less than that of pure milk itself; these two elements can vary, and do vary, between certain limits in pure or normal milk; but when the variations are too great the milk becomes abnormal. Between certain limits, then, a sample of pure milk may have a low specific gravity, owing to a large proportion of water, or it may have a low gravity, owing to a large proportion of fat. In the first case the milk would be poor and thin; in the latter rich and thick. The consistence of two such fluids, a thorough milkman (I mean one posted up to the tricks of his trade) could easily distinguish, and it is, I suppose, on the business principle, that you should only give a man for his money as little as possible, that the milkman, when he finds or receives a quantity of milk that is rich and thick, *partly* skims and dilutes it between certain limits, knowing that the fraud cannot be detected, owing to the fact that the constituents of milk (especially fat) are subject to variation. I am sorry to have to say that this fraud cannot be detected, but it is a fact, and we must grin and bear it, for science never has nor never can offer a method for the detection of such adulteration. Neither chemical analysis nor the various instruments used for detecting adulteration can offer any aid.

Happily, though, for the consumers of this most valuable fluid, the limits between which such adulteration can be carried on are very small, and consequently no very serious results could originate from such adulteration even to infants. If the milkmen would limit their adulteration to this point, we all might be thankful, but unfortunately for us they do not condescend to consult any other source but their pockets. Hence there is forced upon the consumers: "Milk diluted largely with water; skimmed milk; skimmed milk diluted largely with water, and various decoctions called milk, containing any number of adulterants." Fortunately science can interfere with such adulterations and frauds as these, and when they are detected then a severe and just penalty should be pronounced upon the perpetrator, who not only robs the consumers of their rights, but sends many an infant to its grave.

I.—The Adulterants of Milk.

The adulterants, said to be used by different writers for the adulteration of milk, are quite numerous. Although water and, sometimes, chalk, soda, and caramel are practically the only adulterants that are used, the proper treatment of the subject demands the consideration of all the other adulterants, no matter if the consideration extends to the brains of the sheep.

1. *Water.*—This fluid is the most prevalent adulterant of milk—it costs nothing, and possessing a specific gravity less than that of pure milk, the gravity of this fluid may be reduced at pleasure. The amount of water added by milkmen ranges between 10 and 50 per cent. Dr. Chandler,† from numerous and valuable investigations of the milk supply of New York, concluded that the average milk sold consisted of three quarters milk and one quarter added water. The 120,000,000 quarts of milk sent annually to New York receive an addition of 40,000,000 quarts of water, which sold at 10 cents per quart, brings $4,000,000 per annum, or $12,000 per day.

There are a few persons who are disposed to make light of the adulteration of milk by water, but to an educated mind they only display their ignorance. The addition of water to milk or, worse, to skim milk greatly decreases the percentage of the milk solids (as proven in the following table), and consequently renders the milk not only unfit for the food of infants but in many cases dangerous.

Table of the quantities of milk solids contained in 100 parts of a mixture of water and pure milk, in different proportions. ‡

BY CÉSAIRE REYNARD.

Milk.	Water.	Milk solids.	Milk.	Water.	Milk solids.
100	0	12·9200	64	36	8·2688
99	1	12·7908	63	37	8·1396
98	2	12·6616	62	38	8·0104
97	3	12·5324	61	39	7·8812
96	4	12·4032	60	40	7·7520
95	5	12·2740	59	41	7·7308
94	6	12·1448	58	42	7·2016
93	7	12·0156	57	43	7·1724
92	8	11·8864	56	44	7·0432
91	9	11·7572	55	45	6·8140
90	10	11·6280	54	46	6·6848
89	11	11·4988	53	47	6.5556
88	12	11·3696	52	48	6·4264
87	13	11·2404	51	49	6·2972
86	14	11·1112	50	50	6·2600
85	15	10·9020	49	51	6·1308
84	16	10·8528	48	52	6·0016
83	17	10·7236	47	53	5·9724
82	18	10·5944	46	54	5·9432
81	19	10·4652	45	55	5·8140
80	20	10·3360	44	56	5·6848
79	21	10·2068	43	57	5·5556
78	22	10·0776	42	58	5·4264
77	23	9·9484	41	59	5·2972
76	24	9·8192	40	60	5·1680
75	25	9·6900	39	61	5·0388
74	26	9·5608	38	62	4·9096
73	27	9·4312	37	63	4·7384
72	28	9·3024	36	64	4·6532
71	29	9·1732	35	65	4·5220
70	30	9·0440	34	66	4·3928
69	31	8·9148	33	67	4·2636
68	32	8·7856	32	68	4·1344
67	33	8·6564	31	69	4·0522
66	34	8·5272	30	70	3·8760
65	35	8·3980			

* Read before the American Chemical Society.
† Johnson's Cyc., article Milk.
‡ Journal de Chemie Méd., p. 358. 1856.

If the water used to adulterate the milk is not pure, we have danger arising from another source. There is recorded a case* where an epidemic of typhoid fever occurred near Glasgow, Scotland, in 1872-3 by the milkman adulterating his milk with foul water, and allowing his cows to slake thirst from such water. Thirty-two out of thirty-nine families which were supplied with this milk, as also the family of the milkman, were attacked. Families supplied by other milkmen were not affected.

The fever germs were propagated through the adulterating of the milk with this foul water. Another case is reported: "In one of the healthiest suburban sections of London 500 cases of typhoid fever were found distributed in 104 families, 96 of which were supplied with milk from one dairy. The contagion was traced directly to the water used for washing the milk cans and retained in the milk, the water being previously polluted by sewer drainage."

All stagnant water contains organisms either animal or vegetable that renders it unsafe to use, or to allow cows to drink. In the case of pure spring water or running water which likewise contains organisms, there is not sufficient organic matter in suspension to promote their development. In the case of stagnant water the organic matter in suspension or in solution creates in the water the proper mediums suitable for the development of living organisms. "It† is no longer mere water—it is a world of microscopic animals and plants which are born, live, and increase with bewildering rapidity. Drink a drop of this water and you swallow millions of minute beings." Use this water to adulterate milk and you furnish more nourishment to these little organisms, which continue to multiply, and then give the milk to an infant for food and you supply with it organisms which are capable of producing violent cramping and purging, as also capable of setting up putrefaction in the tissues.

2. *Chalk.*—This substance is sometimes used to produce a thickness and opacity to milk that has been diluted with water; it is also used to neutralize the acidity in sour milk.

3. *Starch, Flour, Decoction of Barley, Rice, and Emulsion of Almonds and Hempseed* are said to be used to thicken milk and to neutralize the blue color caused by dilution.

4. Cane sugar, dextrine, milk sugar, gum tragacanth, gum arabic, and borax are sometimes used to increase the specific gravity of diluted milk and sweeten the same.

5. Salt (sodic chloride) is used to increase the specific gravity of diluted milk and to bring out the flavor.

6. Tumeric, annatto, caramel, juice of certain roots, such as the carrot or the different flowers, marigold, saffron and safflower, are used to color the fluid so as to hide the blue color due to dilution.

7. Carbonate or bicarbonate of soda is used to prevent the milk from becoming sour, by neutralizing the acidity; also to increase the specific gravity of diluted milk.

8. Gelatin and isinglass have been used to thicken diluted milk.

9. Cerebral matter, sheep's brains, calves' brains, or horses' brains, have been detected in milk. They were used to thicken the milk after first watering the same.

Having enumerated over the adulterants *said* to be used for the adulteration of milk, I will now proceed to the discussion of the second division of the subject, namely:

II.—THE INSTRUMENTS AND METHODS FOR DETECTING ADULTERATION.

The first requisite, before proceeding to apply a rapid and practical test to the examination of milk, is to ascertain the nature of the adulterants used, so as to know what has to be coped with in the examination. If a given sample of milk, known to be adulterated with several of the adulterants mentioned above, is presented to a chemist to discover the nature of the adulterants, the only method for arriving at the required result is by chemical analysis. Knowing the adulterant or adulterants used, then a more rapid method may be adopted for their detection. It is well though, in large cities, from time to time, to make analyses of the adulterated fluid, to ascertain whether or no the adulterant or adulterants have been changed; this safeguard is only necessary, though, in my opinion, to establish the nature of the adulterants used. Experience has demonstrated that water is in 99 cases out of 100 the only adulterant used for the adulteration of milk. This has been clearly demonstrated in this country, in England, Scotland, France, Belgium, Germany and Switzerland. Let us now consider the instruments and methods for detecting its presence in commercial milk.

DETECTION OF THE ADULTERANT, WATER.

The detection of water, when employed as an adulterant of milk, is not always possible, for two reasons: 1st, because science does not offer any method for distinguishing the water naturally present in milk and the *added* water; 2d, because the percentage of water varies so much in pure milk, that it is only possible to detect added water when the quantity present exceeds the maximum quantity in pure milk. No matter what method we adopt to detect adulterated milk, whether it be chemical analysis, the lactometer, the microscope, or the various other instruments and methods to be described, a standard which shall represent the poorest pure milk has got to be adopted. When it is desired to use the specific gravity of milk as a test for its purity, the specific gravity adopted as a standard must represent the gravity of the whole pure milk.

To determine this gravity any number of experiments have been made; but, before proceeding to the consideration of the different experiments, let us glance for one moment at the various specific gravities stated by prominent writers which are given to represent the weight of milk:

SPECIFIC GRAVITY OF COW'S MILK.

1·030 to 1·039	Simon.[1]
1·0302—1·0396	Vernois & Becquerel.[2]
1·026—1·032	Scherer.[3]
1·0295—1·0343, average 1·0317	Fleischman.[4]
1·0324 (average)	Brisson.[5]
1·0288—1·0364, 1·0322 (average)	Quevenne.[6]
1·0284—1·0357, 1·032 (average)	Macadam.[7]
1·032 (average)	Wiggin.[8]
1·029—1·040, 1·032 (average)	Mott.
1·02958—1.0354, 1·03184 (average)	Jepson & Gardner.[9]
1·02958—1·03538, 1·03219 (average)	Waller.[10]
1·029—1·034 (whole milk)	Hassel.[11]
1·026—1·031	Hassel.[12]
1·028—1·032	Wilson.[13]
1·026—1·036	Atcherley.[14]
1·029	Gorup v. Bessaney.[15]
1·030 (lowest)	Marchand.[16]
1·029—1·034	C. Müller.[17]
1·031494 (average)	J. Blake White.[18]

[1] Animal Chem., Eng. ed., p. 50.
[2] Anal. d'Hygenie, Publ. Avril, 1857.
[3] Physiol. von Dr. Wagner, 1850, p. 450.
[4] Jahrsb. Th. Chem., XIII.-XV. (3), p. 237.
[5] Rees' Ency., 1819, article "Milk."
[6] Dict. Ency. des Sci. Méd., p. 130.
[7] Amer. Chem., 1875, May, p. 419.
[8] Report, 1870-71, Providence, R. I.

* See Willard's Practical Butter Book, p. 24.
† Scientific Conversations, by M. Porville, of Paris.

In reviewing the above figures quite a difference will be observed; but, fortunately, this difference can be readily explained. The object of most experimenters has been simply to determine the specific gravity of the particular samples they have had under examination, and their results are correct for those particular samples, but incorrect if they are meant to represent the specific gravity of *all the milk* from a milking thoroughly mixed together.

When I speak of the specific gravity of the milk of a cow, I mean the specific gravity of all the milk from the cow (in perfect health) thoroughly mixed together, obtained at her regular hour of milking, not the specific gravity of the first, middle, or last portion, for each of these portions give an entirely different specific gravity peculiar to themselves. The following are tests of the first and second drawn milk from eight different cows:*

First drawn milk.			Second drawn milk.		
Cows.	Specific Gravity.	Cream.	Cows.	Specific Gravity.	Cream.
1....	1·027	9	1...	1·023	25
2....	1·026	13	2....	1·023	22
3....	1·027	8	3....	1·025	10
4....	1·029	7	4...	1·024	15
5....	1·030	11	5....	1 024	32
6....	1·030	8	6....	1·022	25
7....	1 029	3½	7 ...	1·026	7½
8....	1·031	2	8....	1·030	5
Total...		61½	Total...		141½

Schübler found that, on fractioning the milk at a milking, the—

	Specific Gravity.	Cream.
First portion showed	1·0340	5 per cent.
Second " "	1·0334	8 " "
Third " "	1·0327	11·5 " "
Fourth " "	1·0315	13·5 " "
Fifth " "	1·0290	17·5 " "
Average	1·0321	11·0 " "

Jebson & Gardner, Milk Inspectors for New York, found the milk and strippings of two cows:

		Entire Milk.	Strippings.
First cow	Specific gravity	1·0348	1·02610 lact. 90
Second cow	" "	1·0319	1·02668 lact. 92

What, then, is the specific gravity of cow's milk? Or what is the range of the specific gravity? I have already stated that a number of experiments have been made to determine this important point, and we will now proceed to consider them:

Dr. Fleischman,† of Germany, personally inspected the milk of thirteen different dairies in the vicinity of Linden, containing in the aggregate one hundred and twenty-three cows. He noted the specific gravity of the milk of each cow separately and upon each day, in bulk, with the following results:

"The mean specific gravity from the 123 cows is 1·0316908." "The maximum specific gravity of any one of the 123 cows is 1·034300, and the minimum specific gravity from any one of the 123 cows is 1·029500." "The milk of 9 per cent. of the cows exceed 1·033 in specific gravity." "The milk of 89 per cent. of the cows ranged from 1·033 to 1·030 in specific gravity, and the milk of 2 per cent. of the cows was below 1·030 in specific gravity." "The mean specific gravity of the milk from the 13 dairies ranged between 1·03065 and 1·03285, or, in round numbers, between 1·031 and 1·030."

Quevenne‡ tested the milk from 103 cows, his experiments extending over a period of eleven years. He found the average specific gravity 1·0322, and for the range 1·0288 to 1·0364. He only found *one* sample of specific gravity 1·0288; he found six samples between 1·029 and 1·030, five samples above 1·035, and ninety-one samples between 1·030 and 1·035.

Dr. Steven Macadam§ made a number of tests at three large dairies in the neighborhood of Edinburgh. He found the specific gravity to range from 1·0284 to 1·0357; the average of forty-four trials of different milks being 1·03220. The milk was taken direct from the udders of the cows.

He found only one sample of specific gravity 1·0284, one of 1·023, one of 1·0294, and one of 1·0296. All the other samples had a specific gravity between 1·0304 and 1·0357.

Jebson & Gardner‖ tested the milk of 109 cows (45 Harlem and 65 Orange Co., N. Y.); they found, for the average, the special gravity 1·03184, for the range 1·02958 and 1·0354.

Dr. Waller tested the milk of 86 cows and obtained the average special gravity 1·0321, and for the range 1·02958–1·0353.

Dr. J. Blake White¶ tested the milk of 129 cows at six dairies, making 142 examinations, and found the total average specific gravity 1·031494.

Lastly, Dr. Christian Müller** had made under his control "in the newly erected manufactory of condensed milk of the Swiss Company, Moléson," a large number of milk tests. Out of the first 280 weighings in the month of March, 1872, only two cases were found under 1.030, namely, 1·0286 and 1·0298. Over 1·033 to and with 1·034 there were twenty cases; over 1·034 only two, the highest being 1.0344. Two

[9] City Record, July 29, Oct. 7, 1875.
[10] School of Mines, Columbia College.
[11] Adulteration of Food, new ed., p. 408.
[12] Adulteration of Food, old ed., p. 216.
[13] Handbook of Hygiene, p. 42.
[14] Adulteration of Food, p. 61.
[15] Physiol. Chemie., p. 332.
[16] Mémoires d'Agriculture, Paris, 1858, p. 305.
[17] Anleitung zur Prüfung der Kuhmilch, p. 47.
[18] City Record, Aug. 17-24, 1876.

* London *Lancet*.
† Jahresb. Th. Chem., XIII.-XV. (3), p. 237.
‡ Dic. Ency. Sci. Méd., p. 130.
§ Amer. Chem., May, 1875, 419.
‖ City Record, July 29 and Oct. 7, 1875.
¶ City Record, Aug. 17 and 24, 1876.
**Anleitung zur Prüfung der Kuhmilch, p. 55.

hundred and fifty-seven weighings varied between 1·029 and 1.033. "As the average of all the tests," he says, "I obtain a figure which is only a very little larger than 1·031. With respect to the milk which gave the specific gravity 1·0286, it came from a spayed cow, which was already fattening and gave daily two quarts of milk that had, moreover, a bitter taste."

From the above most elaborate experiments an unprejudiced mind will not hesitate to say that the specific gravity of the *whole milk* from cows in perfect health will never fall below 1·029. And if we see stated the specific gravity of a cow's milk below 1.029, we may be sure that either the milk is abnormal, the sample tested not a fair average of all the milk that could be obtained from the cow at her regular hour of milking, the sample has been tampered with, the instrument used to obtain the specific gravity incorrect, or that the temperature at which the specific gravity was obtained could not have been the conventional temperature 15°, 5 C. (60° F). With respect to the two samples recorded one by Quevenne and the other by Macadam, which gave a gravity slightly below 1·029 within 6 ten thousandths, it is evident that some of the above-mentioned conditions were overlooked.

No better proof is necessary to my mind than the fact that it took the examination of the milk from over 850 cows to produce two such samples

The minute we find a property of milk that is constant, or, if it varies, does so between certain limits that can be definitely fixed, that minute this property becomes a standard and test for the purity of milk. And it is for this reason that an instrument can be constructed, based on the fluctuating gravity of pure healthy cow's milk, the indications of which will be infallible.

The original Galactometer discovered by Cadet de Vaux,* in 1817; the Centesimal Galactometers; the Lactodensimeter, discovered by Quevenne,† in 1842; the Lactometer, discovered by Edm. Davy,‡ in 1821; the Milk Tester, discovered by Greiner, in Berlin, in 1834; the Milk Weigher of Mollenkopf,‖ Dörssel, and Geissler, in Stutgart; and the various other lactometers are such instruments, which are all Hydrometers, and differ from each other in the graduation of their scales.

(*To be continued.*)

THE USE OF SALICYLIC ACID IN THE HOUSEHOLD.

By DR. VON HEYDEN.

1. *Raw Meat.*—It frequently happens, especially in warm weather, that meat, particularly such as contains easily decomposable fat and blood (tongues, etc.), although otherwise irreproachable, upon closer examination or upon boiling gives off a disagreeable smell. This may easily be removed either by laying the meat before cooking in lukewarm water containing ½ to 1 gram of salicylic acid to the litre, or by throwing some small crystals of acid into the water during the boiling.

When it is desired to preserve meat for some days, it is recommended to lay it in a solution of salicylic acid in water, ½ to 1 gram to the litre; or to rub lightly salicylic acid into the meat, especially the bones and fat parts. The preservation, as well as the cleaning for the dressing, is done in the usual way.

Although meat treated with salicylic acid loses its red color on the exterior, it undergoes no change internally. Moreover, it becomes tender with less boiling.

2. *Milk.*—Pure cow's milk, to which dry salicylic acid (not in aqueous solution) has been added in the proportion of ½ to 1 gram to the litre, curdles at the ordinary temperature after about thirty-six hours, retaining its properties, the cream separating and yielding butter perfectly.

3. *Butter* kneaded with water containing ½ to 1 gram of salicylic acid to the litre, or packed in cloths saturated in such a solution, remains good longer than usual. Butter that has already become rancid can be improved by careful washing with aqueous solution of salicylic acid (2 to 3 grams to the litre) and afterwards rinsing with pure water.

4. *Preserved fruits* (cherries, currants, raspberries, plums, apricots, peaches) may be prepared advantageously, by placing layers of fruit and sugar alternately, without water, in a not very wide-mouthed pickle bottle, strewing over them a pinch of crystallized salicylic acid (about ½ gram to a kilo of contents), closing the jar with parchment paper that has been steeped in a solution of salicylic acid, and boiling the bottles in the ordinary way in a water-bath. Bilberries are best boiled without sugar, allowed to cool, filled into a narrow-mouthed flask, some crystallized salicylic acid strewn over, corked, etc. Fruit thus preserved has been kept in excellent condition during two seasons. Another method is to lay over the surface of fruit preserved in bottles, a closely fitting piece of blotting paper that has been steeped in a strong solution of salicylic acid in rum. Preserved gherkins may be similarly treated. For those preserved in vinegar and sugar (*Essiggurken*) the salicylic acid is boiled with the vinegar, and when boiled poured over the gherkins. For salt gherkins (*sauer gurken*) the acid, ½ to 1 gram to the litre, is added during the boiling; in other respects the preparation is as usual.

5. *Preserved vegetables* and similar articles may also have a small quantity of crystallized salicylic acid added.

6. *Fumigations.*—Dry salicylic acid, volatilized from a hot plate, purifies the air and perfectly disinfects the walls of a closed room.

7. *Vessels, Corks, etc.*, to which a disagreeable smell or taste attaches, are thoroughly purified, by washing in solution of salicylic acid.

The solutions of salicylic acid for the above purposes are best prepared by rapidly boiling the acid in water, in the proportion of from 1 to 3 grams to the litre, and leaving to cool. Any excess that then separates is fit for fresh use; or if stirred up and used in suspension causes a corresponding increase in the action of the solution.

THE FLUORESCENT MATTER IN ATROPA BELLADONNA.

By R. FASSBENDER.

THE author publishes some further information respecting the blue coloring matter discovered by Richter. It is found in all parts of *Atropa Belladonna*, and is distinguished by its great permanence and the strong fluorescence which can be recognized even when extremely diluted. The author found it in all the commercial extracts of belladonna he examined; whether commercial specimens of atropa and its salts are free from this substance he is not in a position to say.

In order to show how extremely small a quantity of this substance can be distinctly recognized, the author crushed two unripe belladonna berries in some water, evaporated the liquor in a water-bath, treated the residue with alcohol, filtered, evaporated the solution, and again dissolved the residue in water. The filtered solution, which perceptibly reddened blue litmus paper, was digested with animal black, which absorbed the coloring matter; the charcoal was treated with alcohol at a gentle heat, a few drops of ammonia added, the liquor filtered, and the charcoal again washed with alcohol. The filtrate was clearly fluorescent, and when diluted with 290 c. c. of alcohol, the characteristic blue color was still distinctly perceptible if looked at from above. The great permanence of this substance may be shown with a few drops of a less dilute solution mixed with a drop of ammonia in a watch glass; after the rapid drying up of this liquid upon a warm day the reaction is reproduced by the addition of more ammonia. Besides the coloring stuff, there is obtained by the above method of preparation a yellow resinous body extremely insoluble in water and very soluble in alcohol.

COLOGNE WATER AS AN ANÆSTHETIC.

AT a recent meeting of the Nice Society of Medicine, Dr. Hughes presented some observations upon the anæsthetic influence of Eau de Cologne, which he had recently noticed. In one instance, that of a young lady afflicted with tubercular consumption, and with whom injections of morphine and the use of chloral had failed to produce the desired repose, a friend suggested a trial of Eau de Cologne, which she had already used with success in similar circumstances on some twenty different occasions. An immediate experiment was made by placing a handkerchief well moistened with Cologne under the nostrils of the invalid, who, in the space of seven minutes, sank into a profound slumber. The same experiment was repeated in another case in the same family, with a like result. The sleep lasted from half an hour to an hour. During the inhalations the pulse remained at 75, and there was no period of excitation.

Mr. Hughes had not made prolonged experiments. He thinks the anæsthetic effect of Eue de Cologne should be looked for as proceeding less from the alcohol than from the various odors, or rather from the combination of these essences in the perfume. This effect of perfumed spirits has previously been noted, but a fresh mention of the experiment may lead to other essays, furnishing more conclusive results.

SYMPATHETIC RESONANCE.

A PAIR of Kœnig Ut^4 forks will show the phenomenon of sympathetic resonance at much greater distance than a pair of Ut^3 forks. The common explanation is that as double the number of impulses are delivered in a second, double the energy is conveyed to the distant fork. This is questioned by Mr. Robert Spice (*American Journal of Science and Arts*), in view of the law of forces radiating from a centre. At twenty feet, in fact, the intensity of resonance of Ut^4 forks is undoubtedly greater than the intensity of Ut^3 forks at six feet. With Ut^3 forks of bell metal he got, at forty feet, a greater result than that obtained with the steel Ut^4 forks of Kœnig. The hypothesis he offers is this: "The intensity of sympathetic resonance of forks on their cases increases with the angular deviation or the motion of the prongs." By means of an electro-chemical registering apparatus Mr. Spice finds that when a fork (between Ut^3 and Ut^4) is in vibration, its stem, or handle, alternately rises and falls in accord with the period of the fork, through about $\frac{1}{16}$ inch. In sympathetic resonance the case gives the stem this up and down motion, which is conveyed to the prongs and sets them in motion, as a hand might start a pendulum suspended from it (by moving laterally, say, one inch each way). This motion of $\frac{1}{16}$ inch may be looked upon as constant. If we decrease the length of the fork without altering the constant, we thereby allow of a greater initial angle, the result of which is the same as shortening the pendulum cord. Thus we are in a position to explain the deportment of the bell-metal forks. The velocity of sound in bell-metal is much less than in steel; hence, retaining similar thicknesses in both cases, an Ut^3 fork in bell-metal would be shorter than an Ut^3 fork in steel. Therefore, though we retain the vibration number, we gain advantage from the shortness of the fork, and hence from the increase of angular motion of the prongs.—*Nature.*

HOW TO PRINT IN CARBON.

"I SUPPOSE you have the materials on hand, and your negative ready. Take a piece of the tissue, about two feet, and steep it in a solution of bichromate of potassium, one oz. to forty of pure water; make up 3 oz. of bichromate and 120 of water, which can be used three or four times; put it into a tin dish, or anything; roll your tissue backwards and forwards in it until you get it to lay smooth; leave it in two minutes, and pull it out over the dish and hang up to dry; while in this wet state it is not sensitive to light, and can be done in daylight. I prepare it in the evening a little before dark; be careful to have no dust or bad odors about where you dry, and keep your tissue. It takes several hours to dry, and cannot be dried by the fire, the room must have dry atmosphere in it. When dry, or nearly so, it is very sensitive, and must be kept in the dark or yellow light in a tin box. It is most sensitive when the weather is a little damp.

"The negative that you print from must always have yellow or black paper around the edge, so that the light does not touch the edge of the tissue printed on. As you see nothing on the tissue when printed, you see the photometer with the little numbers on it, and put a small slip of silvered paper according to the instructions you have received, and print to between three and four visible; make a few trials and develop, and you will soon find out the right time. It varies according to the strength of the negative and the state of dryness of the tissue, which is one of the most important things to study, so as to regulate your time. It requires patience to learn, the same as everything else.

"When printed, put your tissue in cold water, but first prepare a porcelain plate of polished glass, the size or a little larger than your tissue print; rub some of the wax solution on the plate, then coat it with plain collodion, which, when set, immerse in cold water till the water runs smoothly over the plate; then take your tissue print which is in the water and lay it on your collodionized plate which has water on it, so that you can more easily move your print into its right place; put it on a flat table or board, lay your rubber cloth on and pass the squeegee over it gently, which drives off the water and any air bubbles, leave it for ten or twelve minutes under a flat-iron or any weight with a piece of blotting paper under, then put it in a dish of pretty warm water and when you see it commence to turn black all around the edges, which it does in five or six minutes, or often much less, you can take hold of the paper by one corner and very gently turn it back; do not let it slide, but lift carefully, which paper you throw away. The tissue is then on your white porcelain, and if you gently throw the warm water with one hand on it, the picture will develop by itself beautifully and gradually, till it is fully out; if too light you will know you must print it more, or, if too dark, less. When properly developed, pour a concentrated solution of alum over it to harden it, then wash for a minute under a tap of clean cold water, and put it in your rack to dry. When dry, touch out any spots with lead pencil, looking through by transmitted light at the time of working on it, so as to get the right tint; then cut out a piece of transfer paper the size of your print, put it in a solution of warm water and lay the slippery side on your carbon tissue; put the rubber cloth on and squeegee as you did the first time, to drive off bubbles and water. Leave it to dry, then pull it off; you cut and mount the same as the other prints, and burnish; practice and have patience till you succeed, and you will be happy. Read carefully Lambert's instructions after you have worked at it, and you will understand them better then. You cannot use too much care and cleanliness, and patience, too, is a great essential."

The above very interesting account was furnished to a lady by C. Gentile, of Chicago, who is willing to help teach as well as learn. We hope others engaged in the carbon and Lambertype processes will also give us some of their experience in such notices, for that is the way to learn, from others' failures, as well as successes.—*Practical Photographer.*

POLARISCOPE OBJECTS.

THE following is an interesting combination: When the polarizer and analyzer are crossed, insert a concave plate of quartz cut parallel to the axis, with its axis inclined at 45° to that of the polarizer, add to this a quartz wedge cut also parallel to its axis, having its axis placed perpendicular to that of the concave plate. The colored circles, shown by the concave plate alone, will be seen to be displaced in the direction of the thicker edge, to a distance dependent upon the angle of the wedge. Also, as the wedge is made to slide in or out, the circles will be seen to expand or contract, according as the thicker or thinner part of it is presented to the field of view.

The explanation of this is to be found in the fact that a combination of two crystalline plates is optically equivalent to a single plate, whenever the axes of the plates are either parallel or perpendicular to one another. This follows immediately from a comparison of the mathematical expressions for the intensity of light at any part of the field in the two cases. The expressions will be found in Verdet (Oeuvres, tome vi., p. 110), who further remarks that, if the two sections are parallel, the addition of the second is equivalent to an augmentation, or a diminution of the thickness, according as the two plates are both positive or both negative, or are one attractive and one repulsive. If the principal axes of the plates are perpendicular, the addition of the second plate is equivalent to a diminution of the thickness when the plates are of the same sign, and to an augmentation of thickness when they are of opposite signs.

When, as in the case proposed, the second plate is a wedge, the effect of the combination will be the same as if the flat side of the concave plate were cut away wedge-wise, but in direction opposite to that of the actual wedge. Optically, then the bottom of the concavity will be thrown towards the side on which the combination is optically thinnest: *i. e.*, on which the actual wedge is thinnest.

The sliding of the wedge will not alter the displacement of the center, which is dependent on the angle, and not on the thickness of the wedge, but it will alter the total thickness of the compound plate, and consequently the diameter of the circle.

In addition to the above, I may mention another piece devised and constructed for me by Mr. C. D. Ahrens. This consists of two quartz cones, one hollow, the other solid, fitting into one another; one cone is of right-handed, the other of left-handed, quartz; and the axis of each is parallel to that of the crystal. The polarization figure due to this combination is, of course, a series of concentric circles, which expand or contract when the analyzer is turned in one direction or in the other.

If the field of view be examined at various distances from the centre, it will be found that there is a distance, viz., where the right and left handed cones compensate one another, at which there is no color but only an alternation of light and darkness. In the immediate neighborhood of this the red and orange assume the brown and drab hues due to low illumination, in accordance with Helmholtz's experiments; beyond this the colors are more brilliant; while at still greater distances, where the thickness of one cone much exceeds that of the other, the colors become more pale.

W. SPOTTISWOODE.
—*Nature.*

COLORED BELTS ON JUPITER.

IN connection with the supposed periodicity in the appearance of marked color on the belts of this planet, the observations of Gruithuisen, of Munich, in the years 1836–40 possess interest. They are found in his *Astronomische Fahrbuch*, 1839, p. 76, 1840, p. 99, and 1841, p. 101. He first noticed the color on April 23, 1836, at 9½ h., when, observing with a 30-inch refractor of 2½ inches aperture, and power 150, the single central belt then visible had a brown tint throughout, and he states that, hardly believing his own vision, he called a person who was at hand, and on asking him what color the belts presented, he replied "the color of rust." With a 5-feet telescope, power 120, the brown tint was not distinguished. On subsequent occasions he found that with the highest powers of the telescope the belt appeared of a bright reddish brown, while with the lower powers it was merely of a dark shade, and hence concluded that the intensity of light was disadvantageous to discerning the color. In addition to the brown tint of the central belt, it was remarked that the planet near its north pole had a bluish-grey tint in May, 1836; a few months later Dr. Albert, a pupil of Bessel, observed with a 30-inch telescope, found the polar region "quite blue." The length of Gruithuisen's descriptive remarks prevents their being transferred to this column, but we refer to the observations, as his annual volumes are not often met with here, and the fact of such observations having been made forty years since may not be generally known. That these tints should have been conspicuous with such small optical aid is worthy of note.—*Nature.*

* Fallenberg Landw. Bl. v. Hofwyl., V. 1817, p. 19.
† Instruction pour l'usage du lactodensimètre, suivre d'une notice sur le lait. Paris, 1842.
‡ Tillock, Philosophical Magazine and Journal, No. 282, Oct., 1821, p. 241.
‖ Rueff, die Controlledes Milchhandles—Stöckhardt Zeitschrift für deutsche Landwertha, 1859, p. 84.

SOME EARLY EXPERIMENTS WITH LIGHTNING.

Sigaud de la Fond compared him who should attempt to capture the lightning and to use it for electrical experiments to the ancient hero who, cuirassed in triple brass, was the first to trust his life to the hazard of the waves. Benjamin Franklin proposed the risk. In a letter written in 1750 he says, "In order to decide whether thunder clouds are or are not electrified, I propose to construct on the summit of some lofty tower or steeple a kind of sentry box (see Fig. 1, for which with the other engravings here given we are indebted to *La Nature*) large enough to contain one

Fig. 1.

man and an insulating stool, and to keep both well sheltered and dry. If from the middle of the stove there starts a bar of iron, curved toward the door, then carried vertically upward for twenty or thirty feet and terminating in a sharp point; by means of this conducting rod the man standing on the stove may be electrified by the low flying storm clouds. If there be any danger to fear for the man, although I am persuaded that there is none, he must step off the stool, stand on the floor of the sentry box, and every now and then bring near the bar a hook of brass wire which leads up to the metal covering of the roof. With this apparatus, if the rod becomes electrified, the sparks will pass from rod to wire without touching the man."

D'Alibard, an amateur in physics, had the boldness to carry Franklin's suggestion into execution. At Marly-la-Ville, he says, in a memoir read before the French Academy of Sciences in 1752, in a meadow on elevated ground he erected an iron rod about an inch in diameter and forty feet in length, having a steel point. A triangle of three posts, thirty feet or so in height, was erected, two posts being attached to a garden wall and the third standing alone. All three were strongly braced by beams and cordage. Against the wall the sentry box was arranged, the insulating stool being merely a piece of plank supported by four wine bottles. The arrangement is exhibited in Fig. 2, which is a fac-simile of a wood-

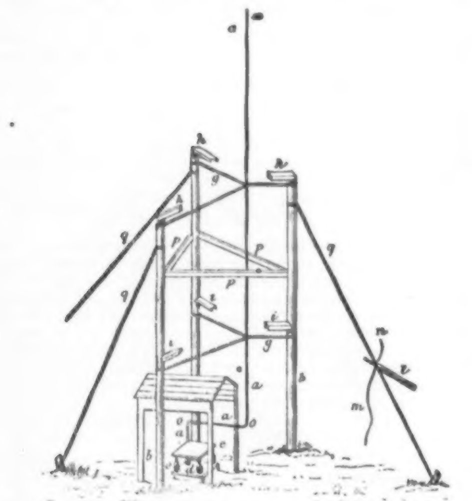


Fig. 2.—FIRST LIGHTNING ROD PROPOSED BY FRANKLIN.

cut of the period. The iron rod was attached to the posts by silk cords, and its lower end bent twice so that the water should not flow down to its base, was connected with the insulating stool. Horizontal pieces, *h* and *i*, were used to shelter the silk cords. The protecting device for the observer was simply a piece of brass.

On May 10, 1752, an old soldier named Coiffier, probably as ignorant as was Alibard himself of the dangers of receiving a lightning stroke *via* the rod, noting the advance of a thunderstorm determined in the absence of Alibard to experiment on his own account. Accordingly he mounted the stool, presented the wire to the rod, and obtained a fine spark; then another even more brilliant. He at once called all his neighbors, and some one ran in search of the parish priest. The latter was seen making his way to the apparatus in such undignified haste, that it was immediately surmised that the daring Coiffier had fallen a victim to his bold experiment, and accordingly the good father found himself the leader of a miscellaneous mob of villagers. Regardless of the pouring rain and hail, the crowd surrounded the machine and there in open-mouthed wonder watched the priest himself draw sparks from the rod. But both the clergyman and the soldier managed to get lightly struck—so slightly that in their absorbed attention to the sparks they scarcely noticed the occurrence until afterwards, when each, feeling stinging pains in their fore-arms, searched for the cause and found bright red stripes on the flesh, just as if a few sound lashes had been administered. There is no doubt but that the villagers saw no good in these supernatural manifestations, and when they all perceived about the persons of the priest and his companion a marked sulphurous odor, due of course to the ozone generated, they were confirmed in their ideas that the powers of the nether world had been evoked.

The remarkable experiment above detailed (we add a sketch of the scene from an old print) resulted in others being undertaken. Delor of the University erected a pole 99 feet high and obtained fine sparks; others followed, and investigations into the phenomenon began in the laboratories of all the scientists. But these wise gentlemen did not play with the lightning unscathed. Scarcely was there one that could not show its marks on his person. A soldier, employed by Abbé Chappe to turn his electrical machine, underwent the same experience which Professor Tyndall has so graphically described: the reception of a heavy charge of static electricity, which knocked him heels over head among the apparatus, smashing the same, and leaving the victim insensible for an hour. Finally, the terrible death of Richmann, of St. Petersburg, occurred, and for a time the physicists suspended

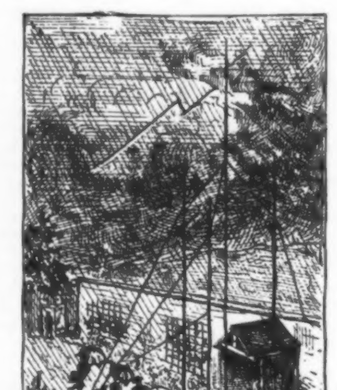


Fig. 3.—THE MARLY-LA-VILLE EXPERIMENT.

their dangerous experiments. Richmann was struck by ball lightning, a variety which M. Gaston Planté has only very recently explained (see Supplement, No. 61), and which possesses an explosive power comparable to that of the most potent torpedoes, yet greater. The unfortunate man was standing near a rod which he had carried up through the roof of his house, and was in the act of presenting to it an electric gnomon in order to measure the degree of electrification of the passing clouds. The gnomon was simply a metal rod entering a glass vase at the bottom of which copper filings had been placed, though for what purpose it is hardly possible to divine. At the end of the rod there was a thread which, when not electrified, hung vertically, but which otherwise stood out at various angles. Richmann was bending over his instrument, and Solokow, an artist, was standing by, ready to sketch the phenomena which might occur. Suddenly the latter perceived a globe of blue fire, about as large as a man's fist, leap from the rod of the gnomon toward Richmann's head, scarcely a foot distant. At the same instant Solokow was violently thrown down. On his recovering consciousness, he found the apparatus shattered into minute fragments, the door of the room crushed and thrown over, and even the woodwork of the apartment was everywhere split. Richmann was dead. The lightning had passed through his body, and made its exit by the left foot. On the forehead were a few drops of blood, although the skin was not broken. There was a blue mark on the foot and a hole pierced clear through the sole of the shoe. On the side of the body were red and blue spots, as if burned. Thus perished the first martyr to electrical science.

Fig. 4.—RICHMANN STRUCK BY GLOBE LIGHTNING.

Among the new inventions for determining the degree to which air is electrified was that of Abbé Nollet, who made shortly the experiments at Marly-la-Ville. He devised the apparatus, as represented in Fig. 5, for leading the electricity into a room so that it may be examined. At E F

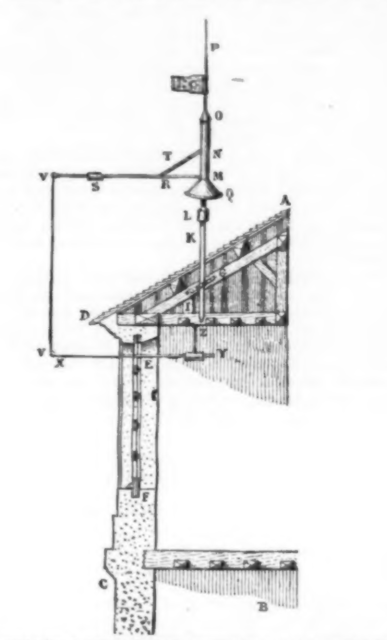


Fig. 5.—NOLLET'S DEVICE FOR STUDYING ATMOSPHERIC ELECTRICITY.

is a garret window, K is a wooden rod extending about 4 feet above the roof, and surmounted by a tin socket which receives a tube of thick glass, L M, which in turn supports a tin tube, N O. The latter, about 5 inches in length, is surmounted by an iron rod, O P. The cone Q serves to protect the glass from becoming wet by the rain, and attached just above this cone is the upper horizontal rod of the frame R V X E. The end, Y, enters the garret through one of the window panes, and is supported by the rod, Z. The collected electricity is thus led into an apartment, where it may be examined.

About this period also Abbé Poncelet conceived the idea of lightning shelters, or structures in which people might take refuge during thunderstorms. He had no notion of lightning rods, nor did he believe that such could serve any protective purpose, but he proposed to make his structure of a frame of resinous wood covered with three thicknesses of waxed cloth. Inside the tent was to be lined with silk. "Suppose now" the inventor quaintly says, "that the thunder happens to fall on this little edifice, what will happen?

Less than nothing. As it presents on all sides resinous surfaces, which never receive phlogiston by communication, the latter, after having leaped lightly around the pavilion and finding itself unable fo attack it, will propably depart in order to pursue its ravages elsewhere." As a frontispiece to his book, Abbé Poncelet has a picture which we reproduce in Fig. 6, representing the interior of his pavilion. He himself is standing in the center withdrawing sparks from a rod which descends from the roof, while the lightning and storm clouds harmlessly surround the structure.

While Franklin was pursuing his electrical experiments in the United States, an unknown provincial magistrate named

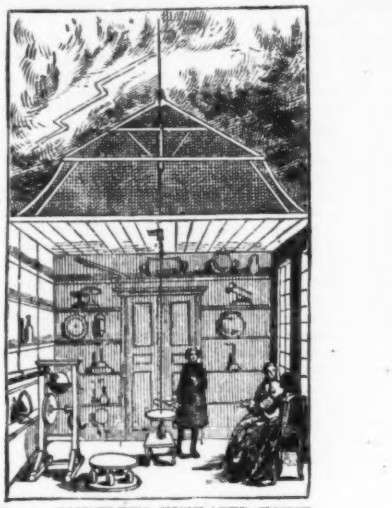


FIG. 6.—PONCELET'S INSULATED HOUSE.

De Romas was likewise making researches with the greatest zeal. He, like Franklin, suspected the analogy between lightning and electricity, and was led to the idea by phenomenon of attraction, of which he was witness, caused by a

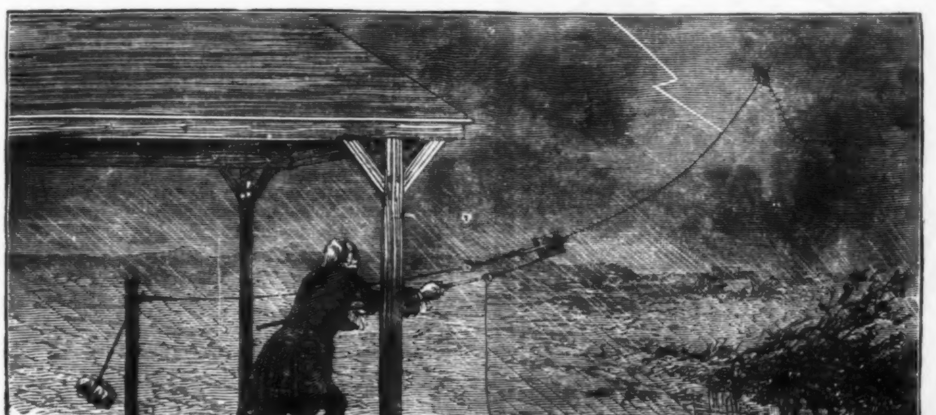


FIG. 7.—ROMAS' ELECTRICAL KITE EXPERIMENT, 1753.

lightning stroke, which occurred in 1750. In order to produce more powerful sparks, he thought of raising an isolated conductor to a great elevation, and in this way he reached the notion of using a kite as the conductor. Here we meet one of those disputes as to priority which strew the borders of the entire road along which the onward march of invention has progressed. It is unnecessary here to recall the circumstances of Franklin's kite experiment, which De Romas claimed to have anticipated, and it will suffice to state that even, if the French investigator was the first to conceive the idea, he placed his early results on record in such mysterious and confused language that the same furnishes but little evidence in support of his assertion. Some of De Romas' results of later dates are, however, quite interesting. In 1753 he sent up a kite of about eighteen square feet in area, but his cord remained dry and he obtained no sparks; the failure caused both merriment and mockery among those assembled to witness the experiment. Next time he oiled his kite, wound the cord with very fine copper wire, and sent the kite aloft in a thunderstorm. His arrangements worked so well that he obtained shocks which, as he expressed it, made him "feel every point in his body;" and those who doubted the matter and tried for themselves found out to their confusion that he was exceedingly right. With great intrepidity he then assumes the unknown risk of severe shocks. From a glass tube about a foot in length, the end covered with tin and connected by wire to the ground, he made an excitator, Fig. 7, by which he was enabled to obtain sparks seven or eight inches instead of scarcely an inch in length as hitherto. The noise of the discharge was audible at a distance of more than 200 feet, and even as far away as 6 feet the spider web sensation on the face could be felt. Three straws were attracted by the tin tube, danced between earth and tube for some time. Then one touched the tube, a discharge passed through it and made a hole in the ground. The straw then ran up the cord until the kite was attained, which it touched, then retreated, and so kept moving to and fro, at each contact drawing a spark. At this time neither lightning nor thunder was present. A strong ozone odor was noticeable, and the cord was surrounded with a cylinder of light 3 or 4 inches in diameter. Subsequently De Romas found that the danger in the kite experiment was greatest during the raising of the kite, as he himself repeatedly sustained severe shocks during that proceeding. Accordingly he invented a carriage on a reel on which he placed his cord and then dragged his vehicle behind him while running by silk lines, Fig. 8.

The old experiments which we have here detailed, as well as others made at the same period, have proved, as now well known, of great scientific value. They demonstrated the certainty of the fact that lightning only differs in abundance from the electricity which we can easily accumulate in conductors or in batteries.

DUPLEX TELEGRAPHY.

WE have lately had occasion to record, in an incidental way, that a system of duplex telegraphy has been successfully introduced upon some of the lines between this country and India, and the success is of sufficient importance to require a somewhat more extended notice. In the original methods of telegraphy the signal is produced by a battery current, which is passed through the sending station, along the connecting wire, to the receiving station, and then through the earth, back to the battery from whence it came, so as to make a complete circuit. In the course of this circuit the current passes through the recording instrument at the sending station, as well as through that at the receiving station, so that the operator produces his signal upon his own instrument as well as upon that with which he wishes to communicate. It follows that the instrument at the sending station, being thus disturbed by the current which is passing through it, cannot, at the same time, be receiving a message from the other extremity of the line; and electricians have long been engaged in researches with a view to alter this condition of things, and to leave the instrument at the sending station unaffected, so that it may be able to receive messages and to record them.

The difficulties in the way of accomplishing this object were found to be much greater on long than on short lines, and very much greater on submarine cables than upon land lines of whatever length. The latter differ from the former by being more completely insulated; the submarine cables being surrounded by water which is in contact with the earth, and which brings them into direct relation with it. One effect of this relation is that the passage of the battery current along the wire produces an induced current around it, which delays the speed of the battery current, so that this, instead of traveling rapidly, as it does upon land, travels very slowly, and flows out of the wire in a way which has often been compared to the escape of a viscid liquid. For this and other reasons, the submarine lines require to be furnished with recording instruments of much greater delicacy than those which are used for land lines, and the former are, therefore, more liable to be disturbed. The principle on which efforts at the attainment of duplex telegraphy have been made is that if the original battery current is split into two equal parts, these may be conducted around the recording instruments by two different wires proceeding in opposite directions, and may then be conveyed along two different circuits; one half-current serving to excite the recording instrument at the distant station, the other half, after fulfilling its function of "balancing" the needle at the sending station, being simply wasted. The power of the second half-current to balance the recording instrument at the sending station—that is, exactly to counteract the signalling half-current—depends upon the two being precisely of the same strength; and this only happens when the two circuits which they respectively travel are precisely of the same resistance. If the circuit, say to the left, is of less resistance than that to the right, more electricity will flow to the left than to the right; the original battery current will thus be unequally divided, and the recording instrument will no longer be balanced—that is, it will no longer remain at rest while the divided current is passing. On land lines, formed by wires suspended in the air, the resistance of the signalling wire to the current is easily ascertained, and is easily imitated on the second or artificial circuit; but in submarine lines, on account of the induction already mentioned, there is not only the resistance to be taken into account, but also the retarding capacity of the cable. In any given cable, each knot of length presents a certain resistance, and has also a certain retarding capacity; but these two qualities do not bear the same proportion to each other in any two cables, and have to be separately tested in each. The second circuit, which for the land line need only be equal to the signalling wire in resistance, must for the cable be equal to it both in resistance and in capacity; and it has been found very difficult to fulfill both these requirements. It is not enough that the whole of the second circuit should be equal to the whole of the cable, but the resistance and the capacity must be distributed equally in both, and any portion of the second circuit must be equal to any corresponding portion of the cable.

Attempts have been made by Mr. Varley, Mr. Stearn, and others to overcome the difficulty by various combinations of condensers with resistance coils; the former to imitate the capacity, the latter the resistance, of the submarine cable itself. All these combinations seem to have failed from not being sufficiently uniform in their qualities; but Mr. J. Muirhead, Jr., has lately succeeded in obtaining the uniformity which was desired. He has formed his second circuit by sheets of paper prepared with paraffin, and having upon one side a strip of tinfoil, wound to and fro, to represent resistance, and through which the second current is conducted, and on the other side a sheet of tinfoil, to represent the gutta percha or other covering of the wire and to afford the capacity. Each sheet of paper may thus be made to represent precisely a given length of cable, having enough tinfoil on one side to furnish the resistance, and enough on the other to furnish the capacity. It follows that a sufficient number of such sheets would exactly represent the cable in every part of its length, and that the non-signalling half of the current would be precisely equal to and would be discharged under precisely the same conditions with the signalling half. For utilizing this invention two methods may be employed; the two halves of the current being either carried around the recording instrument in different directions, as already mentioned, or the two circuits being connected near their point of divergence by a Wheatstone bridge, on which the recording instrument is placed. Then, as long as the divided current flows evenly, one-half along the signalling wire to the recording instrument at the distant station, the other half along the artificial circuit, the equilibrium of the bridge between the two is not disturbed, and the instrument placed upon it is not affected. But as soon as the operator at the distant station, who has a precisely similar arrangement, sends a battery current into the signalling wire from his end of the line, this meets and opposes the half-current which is coming toward him. The flow through the signalling wire is thus interrupted, and, in consequence, the resistance of the two circuits being no longer equal, the balance of the first recording instrument is disturbed, and is disturbed in a degree which is regulated by the admission of the current from the other end. The result of this is that a single wire will convey signals simultaneously in two opposite directions, and that one wire will do the work for which two have previously been required.

On all marine lines this invention of Mr. Muirhead's is of the greatest possible importance, on account of the enormous expense of laying additional cables to meet increasing traffic; and also because, while it theoretically doubles the carrying capacity of each cable, it does still more than this in practice, by doing away with much loss of time in arranging about the precedence of outward and homeward messages, and about the repetition of those which were not perfectly intelligible at first. The new plan was first tried, on a working scale, on the line between Marseilles and Bona; but it has since been brought into operation from Marseilles to Malta, from Suez to Aden, and, lastly, from Aden to Bombay. On a very recent occasion, when there was a breakdown upon the Indo-European line, the duplex system rendered essential service, and maintained telegraphic communication which would otherwise have been most seriously interfered with. Mr. Muirhead's invention cannot fail to be highly profitable to the proprietors of submarine cables, and it will, we hope, before long, bring about a material reduction in the cost of messages from places beyond the seas.—*London Times.*

FIG. 8.—ROMAS' ELECTRICAL KITE EXPERIMENT.—THE CORD CARRIAGE.

THE MOON.

THE new work by Edmund Neison, F.R.A.S., upon "The Moon and the Condition and Configuration of its Surface," has lately been published in London by Longmans, and is reviewed in the *Academy*, by W. Grylls Adams, as follows:

This extensive work is founded on the basis of Beer and Mädler's *Der Mond*, but contains extensive additions to the results of their investigations as to the configuration of the moon's surface; it not only gives the accurate positions of all the important points as surveyed by them and their predecessors, Schröter and Lohrmann, but, in addition, it gives the results of minute measurements which have been carried on by the author for a period of eight years, and which have enabled him to revise and, in many instances, to correct the lunar map of Beer and Mädler.

The argument by which he upholds the theory that the density of the moon's atmosphere is not less than a three-hundredth part of the density of the earth's atmosphere is fairly reasoned out, and the balance of evidence seems to be in favor of this view.

The author appears to incline to the theory that if the moon every had a denser atmosphere, it may have been absorbed or have entered into chemical combination with substances in the moon's crust. In common with most other writers who have studied the surface of the moon, he says that there is abundant evidence of the action of an agency like water as well as of an atmosphere; and, like them, he offers no satisfactory explanation of how the water and the atmosphere have disappeared.

The plains, occupying more than half the moon's surface, are divisible into dark and light plains.

The dark plains are seen as large dark-grey spots by the naked eyed, when "examined closely, they are seen to be traversed by numerous long ridges, and to contain low hills and mounds, interspersed with small crater-pits. They often present the appearance of alluvial deposits, and in many portions of their borders distinct traces of the apparent action of water can be clearly detected."

The walled plains which are classed under craters scarcely differ in character from the bright plains, except that they have ridges or mountain ranges surrounding them: from these we pass by almost imperceptible gradations through mountain rings to "*ring plains or ring mountains*," the great majority of so-called lunar craters, although they present no appearance of being in reality volcanoes. The portions apparently of volcanic origin are distinguished as crater-plains and craters, and the true volcanoes are termed "crater cones," which cannot easily be distinguished from bright mountain peaks and white spots dispersed over the lunar surface.

Among formations not classed under the three principal headings are the clefts, which are apparently dark beds of lunar rivers, but which are not yet fully accounted for, and the remarkable systems of bright rays or streaks which are seen when the surface of the moon is under high illumination. These streaks extend for some hundreds of miles over all kinds of formations, starting from the principal ring-plains or mountain formations.

The origin of these streaks is as yet unknown; they have been supposed to be connected with some process of surface action, and sometimes they appear to have been overwhelmed or to have been filled up by material from the surface of the plains. Noticing the variety of the tints on various portions of the moon's surface the author says:

"The surface of the moon exhibits every kind of variation of pale yellow, grey, and white, and in many places the yellow merges almost into a pale brown. A very noticeable contrast appears between the greyish-white and white of the brighter portions of the high mountain regions and the walls of the great ring-plains, and the greyish-white and white of the streaks; the former appearing as of considerable intensity and body, with a distinct tinge of yellow, whilst the latter seem to possess a thin bluish-white of little intensity, and almost as if it were semi-opalescent. Similarly the white of the bright craters appears more bluish than yellow, like the ring-plains, though surpassing these in intensity."

The author inclines to the view that variations in the appearance of the nature of configuration as distinct from purely surface alterations are far less extensive than is generally supposed. The conditions of the earth's atmosphere affect the appearances more than the librations of the moon, and the superficial changes such as changes of color or brightness may be due to some process of weathering by the atmosphere.

The description of the details of the lunar surface occupies more than three-fourths of the whole work, and is illustrated by an index map eight inches in diameter, and by a complete lunar map, in twenty-two sections, on a scale of twenty-four inches to the diameter of the moon. In each section the description of each principal formation is followed by the description of the smaller lunar formations grouped around it, so that the peculiarities of any particular object or district may be easily found. One or two passages will give some idea of the difficulties to be overcome, and of the minuteness of the survey which must be made before such descriptions of the surface can be given. Describing the "Sea of Cold," which lies in the North Polar Section (Map VI.), he says:

"This mare appears in full, with a pale yellowish, or perhaps greenish-yellow, glimmer. The whole, especially in not entirely favorable atmospheric conditions, appears as a streak of thin cloud, fog, or mist, stretching across the northern portion of the moon; and when a thin misty cloud is seen extended as a belt across the moon, the similarity between this and the Mare Frigoris is so great that one unfamiliar with the last would take it likewise for a cloud."

Again, in the South Polar Section (Map XVII.), in describing "Maginus," of which the author gives an enlarged map, on the scale of 100 inches to the moon's diameter: "In high illumination, Maginus, as a grand lunar formation, does not appear, only a few isolated points being detectable." "The special map shows the real nature of its constitution, and its entire dissimilarity to the volcanic craters."

The author has eight special maps or drawings of interesting objects on the scale of 100 inches to the moon's diameter, for some of which as many as fifty carefully executed drawings have been made. One of them, Gassendi (Map XII.), is remarkable for its very numerous and extremely delicate systems of rills, which are most difficult features, and are rarely well seen even with very powerful instruments:

"The relation between the configuration of the surface and the position and path of the rills in this group within Gassendi appears very definitely marked, most of them being situated within shallow valleys, this being particularly noticeable towards the south-west of the interior. The influence of hills and similar irregularities in narrowing the rills is also especially marked; and the shadows of these entirely masking those portions during low illuminations, they are readily overlooked. Some connection appears also to exist between the rill system and the peculiar passes in the walls of the formation."

Reasoning from the analogy of the earth, there are several reasons why the atmosphere and water cannot be swallowed up in the interior: for instance, it has been shown that the material of which the earth's crust is made up is not so rigid that it will not yield to the difference of attraction of the moon on its various parts; so that there must be an appreciable tide following the apparent motion of the moon, not only in the oceans but also in the solids which go to the formation of the earth's crust.

If, then, the difference of attraction of the moon on different parts of the earth's crust is sufficient to cause that crust to yield, then the attraction of the moon on her own crust is surely sufficient to bend it inwards and to break it, so as to fill up all large hollows in the interior, especially when within those hollows there would be comparatively little fluid resistance to be overcome.

If the force of attraction of the moon is not sufficient to bend or break the crust, still the difference of attraction of the sun's mass on different parts of the moon will cause a tide in its crust in the same way as the sun causes tides on the surface of the earth.

ICE, BUT NO WATER, ON THE MOON'S SURFACE.

If we picture to ourselves what the state of the moon must be, we shall see that there is abundant reason why there is no water on its surface. Since day and night in the moon are each a fortnight in length, all the water on the side away from the sun would be in a solid state. Shortly after sunrise the ice would begin to melt, owing to the intense heating effect of the sun's rays; even if the density of the atmosphere were one-hundredth of the density of the earth's atmosphere, the water running off the ice would be heated to the boiling point, which would then be only about 7° C, and would be converted into an invisible vapor.

According to Regnault, the maximum tension of the vapor of water at 0° C. is 4·6 mm. According to Neison, the density of the moon's atmosphere at the surface is a three-hundredth part of the density of the earth's atmosphere at the surface; so that the pressure is less than 2·5 mm., which is the maximum tension of the vapor of water at the temperature of—8° C.

Hence water, as a liquid, could not exist in the moon, seeing that its boiling point would be below the freezing point.

If glaciers exist, then the vapor of water will be given off from them as a transparent vapor, and so we cannot expect to see traces of water on the surface.

Hence the non-existence of sheets of water is no argument against the existence of glaciers in the moon, because the glaciers would only disappear by evaporation into a transparent vapor.

If, then, the moon's surface appears to have been acted on by glaciers, we can well believe that they have existed and that they do exist at the present time, and that some of the changes which are observed to be going on may be due to glacier action. These glaciers, if they exist, can only disappear by evaporation under the intense heat of the sun, and no aqueous clouds can be formed. Possibly the twilight at the cusps, and the transient blue fringes seen soon after sunrise, may be due to this rapid evaporation from the surface of these glaciers. On account of the considerable specific heat of ice and the high latent heat of water and its vapor, it is quite probable that the glaciers, if they exist, may not entirely disappear even in low latitudes, although the temperature of the surface may be 200° C. or even 300° C.

The bright craters are said to have a bluish tinge, and the streaks are of a "thin bluish-white, of little intensity," and seem to be connected with some process of surface action, and at times to have been filled up by material from the surface of the plains. May we not here have evidence of the existence, not of white snow, since there is very little air to mix with the ice, but of sheets of ice covering the mountain tops with glaciers flowing from them, which sometimes melt away and leave their moraines behind them?

The delicate systems of rills within the ring-plains also point to some action of a similar kind. They run in shallow valleys, are narrowed by hills and irregularities, and have some relation to one another and to the passes in the walls of the formations in which they are seen.

Here we have indications of something like a glacier system, or of something in a molten or in a half-molten state. These rills are seen at the full moon and near the equator, where the temperature is probably above 200° C. A mass of sulphur would become a river, and running down would again become a viscous solid in the valleys; possibly within the craters the temperature may reach the melting point of tin, and even the boiling point of sulphur. As a limit to the temperature all over the surface, we may say that probably a river of sulphuric acid would still remain liquid even on the boiling surface of the moon.

We have here a wide field for speculation within the limits of the possible, and can only arrive at the most probable solution by patient labor such as for some years past Mr. Neison has devoted to his observations of the moon.

MARQUETRY ORNAMENTS. DRAWINGS OF A. SCHILL, ARCHITECT, STUTTGART.—*(From the Workshop.)*